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UNITED STATES DEPARTMENT OF AGRICULTURE

# FOREST SERVICE

ANNUAL REPORT FOR 1930

OF NORTH PACIFIC INVESTIGATIVE COMMITTEE

AND PROGRAM FOR 1931

March 1931

U. S. GOVERNMENT PRINTING OFFICE: 1931 8—6435

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# ANNUAL REPORT FOR 1930

# OF NORTH PACIFIC INVESTIGATIVE COMMITTEE

# AND PROGRAM FOR 1931

## INTRODUCTION

The North Pacific Investigative Committee met two full days March 3 and 4, 1931; the sessions were presided over by Regional Forester Buck. Those present at part or all of the meeting were:

Members of Committee

C. J. Buck, Chairman
T. T. Munger, Secretary, representing Pac. N.W. For.Exp.Sta.
L. B. Pagter, representing forest supervisors
F. E. Ames, representing Forest Management
J. F. Kummel, " " "
E. J. Hanzlik, " " "
E. N. Kavanagh, representing Range Management
W. L. Dutton, " " "
F. H. Brundage, representing Fire Control
W. B. Osborne, " " "
R. E. McArdle, representing Pac. N.W. For. Exp. Sta.

Other than Committee Members

Allen H. Hodgson, representing Office of Forest Products
H. M. Johnson, of " " " "
E. F. Rapraeger, " " " " "
F. P. Keen, representing Insect Control Station
J. L. Mielke, representing Office of Forest Pathology
T. W. Childes, of " " " "
J. R. Hansbrough, " " " " "
Charles Dague, representing Weather Bureau
L. A. Isaac, of Pac. N.W. For. Exp. Sta.
A. G. Simson, " " " " " "
H. J. Andrews, " " " " " "
W. H. Meyer, " " " " " "
H. B. Shepard, " " " " " "
R. W. Cowlin, " " " " " "
A.J.F. Brandstrom " " " " " "
A. J. Jaenicke, " Forest Management
B. E. Hoffman, " " "
Oliver Ericson, " " "
E. T. Allen, representing Western Forestry & Conservation Ass'n.

To acquaint the Committee with the particular matters which the Washington Office wished to have it consider, portions of Mr. Clapp's letter of December 15 were read, and announcement was made as to the desirability of devoting the discussion to essential matters of policy and minimizing the time spent on detailed discussion of project results.

## GENERAL MATTERS AND RECOMMENDATIONS NOT CONNECTED WITH SPECIFIC PROJECTS

### Distribution of the Investigative Committee's Report

The Committee decided this year to mimeograph its entire report for general circulation instead of preparing a digest for distribution. The individual project sheets which comprise the appendix of the report, however, will not be included in the mimeographed edition.

### Need for a Government Journal Devoted to Forest Research

The Committee was unanimous in feeling that there should be some avenue for the prompt publication of the results of research, which under the present system are either delayed in publication, not published at all, or must be issued through less satisfactory channels.

### Need for the Assignment of a Forest Biologist to Work in this Region

The Committee expressed the hope that the Biological Survey could at an early date assign to this region a forest biologist to specialize on research in the many relationships between animal life and forest and range management.

### Disposition of Permanent Sample Plot Records

Mr. Munger said that it seemed desirable that the long-time permanent sample plot records should not be kept all in one place

because of the possibility of loss in a conflagration. The Committee decided that the sets not kept at the Experiment Station Office should be distributed among the national forest offices concerned for safe-keeping rather than with the Regional Office.

The Balance in the Investigative Program Between the Needs of the National Forests and Those of the Private Timberland Owners and Operators

In line with the Forester's request in his statement on the Studies Committee Report of the District Foresters' conference of 1930 the question was discussed whether the present research program was properly balanced between serving the national forest needs and those of the private operator and land owner. The general opinion was that the program is now well balanced, although the view was expressed that the Products program of the past had not sufficiently satisfied national forest needs, and also that the program of this region should contain more to answer the problems of range management and erosion control on the national forests.

Insufficient Personnel at Experiment Station for Silvicultural Studies.

Mr. Munger called attention to the fact that progress on several silvicultural studies is too slow because of lack of man power, that three men were handling ten projects where six technicians would not be too many to give the problems adequate study. He urged an expansion in this field as soon as possible. The Station, for example, is unable to undertake any major new mensurational project this next year, such as growth and yield of spruce-hemlock in the fog belt, because the services of the one mensurationist, Mr.Meyer, will be required on the growth phase of the forest survey.

Erosion-Streamflow Studies

The movement that is on foot to launch a country-wide program of studies of erosion and streamflow control in their relation to range and forest management, was discussed and commended. Of the projects tentatively proposed for this region, the Committee considered of first importance the problems of the eastern slope of the Cascades in Washington where water for irrigation is so important, and of next greatest importance, sheet erosion as related to grazing and timber cutting in the Blue Mountains of eastern Oregon.

The Economics of Forest Disease Control

The Committee discussed the desirability, as a prerequisite to any disease control campaign, of sound study of the forest economic factors involved. It was the opinion that in the case of white pine blister rust control such economic analysis, based upon the best financial forecasts, had not been made, or at least not published, and that disease control operations should be appraised and adopted, or not adopted, on the basis of such an economic analysis, the same as any other silvicultural or protective forest practice. The Committee went on record as suggesting to the Bureau of Plant Industry that such studies be made in cooperation with forest research agencies and published.

Experimental Forests and Ranges

It was reported for the joint Committee of the Regional Office and Experiment Station on Experimental Forests and Natural Areas that it had decided in a general way upon two experimental forests:

1. Douglas fir type on Trout Creek in the Wind River Valley, Columbia National Forest, where a diversity of conditions may be found close to the existing branch headquarters of the Experiment Station. The boundaries have been tentatively laid out subject to checking as soon as field work can be done.

2. Western yellow pine type near Pringle Falls, Deschutes National Forest, where a tract of some diversity, typical of a large area, and admirably accessible, has been tentatively selected subject to determination of desirable boundaries in a field examination this spring.

No experimental ranges have yet been selected.

Natural Areas

The Committee has had under consideration several natural areas for withdrawal under Regulation L-20 and made progress on the selection of a few. The status of the areas mentioned in last year's report upon which progress toward selection and withdrawal have been made are as follows:

Douglas fir type: Wind River, Columbia National Forest - an area of about 1,000 acres within the proposed experimental forest and adjoining the present 280-acre natural area has been selected and awaits only field examination to be ready for withdrawal.

Yellow Pine type: Metolius, Deschutes National Forest - an area of 1440 acres has been reported upon and is ready to be recommended to the Forester for withdrawal.

Ochoco Divide, Ochoco National Forest - Committee has approved the withdrawal of this area

and final action awaits further field examination and report by the supervisor.

Sitka spruce type: Willaby Creek, Olympic National Forest - field examination made and selection of area approved by Committee. Recommendation for withdrawal only awaits preparation of report by supervisor.

Hemlock-cedar type: Nooksack, Mt. Baker National Forest - Committee has approved selection of this area, and cation for withdrawal only awaits field examination and report by supervisor.

## Technical Personnel of the Pacific Northwest Forest Experiment Station

There have been no losses in the yearlong personnel of the Station during the year, but there have been eleven additions. The yearlong technical force now consists of the following:

| Name | Title | Field of Work |
|---|---|---|
| Thornton T. Munger | Principal Forest Economist | Director |
| R. E. McArdle | Associate Silviculturist | Fire Studies |
| W. H. Meyer | Associate Silviculturist | Mensuration |
| L. A. Isaac | Assistant Silviculturist | Silviculture in the Douglas fir region |
| E. L. Kolbe | Junior Forester | Silviculture in the western yellow pine region |
| A. G. Simson | Scientific Aid | Fire studies |
| Burt P. Kirkland* | Principal Forest Economist | Economics of Forestry |
| Axel J. Brandstrom | Senior Forest Economist | Economics of Forestry |
| H. B. Shepard | Senior Forest Economist | Forest insurance study |
| H. J. Andrews | Senior Forest Economist | In charge Forest Survey |
| R. W. Cowlin | Associate Forest Economist | Forest Survey |
| J. W. Girard | Logging Engineer | " " |
| C. W. Kline | Timber Expert | " " |
| P. N. Pratt | Timber Expert | " " |
| W. J. Wakeman | Timber Expert | " " |
| D. N. Matthews | Assistant Forester | Forest Survey on the national forests |
| W. H. Bolles | Assistant Forester | Forest Survey |
| P. D. Kemp | Assistant Forester | " " |
| E. D. Buell | Junior Forester | " " |
| P. A. Briegleb | Junior Forester | " " |
| F. L. Moravets | Junior Forester | " " |

*On part time employment until June.

## Allotments and Expenditures of Experiment Station

The allotments to date to the Pacific Northwest Forest Experiment Station for the fiscal year ending June 30, 1931 are:

| | |
|---|---|
| Silvical Investigations | $29,580 |
| Forest Survey | 75,700 |
| Forest Insurance (FFC) | 8,930 |
| Economics of Forestry | 6,000 |
| Equipment and Supplies | 350 |
| Improvement | 900 |
| Total | $121,460 |

The tentative allotments for the Fiscal Year 1932 provide for an increase under Silvical Investigations of $15,000, for fire studies but no increase in other items.

During the Fiscal Year 1930 expenditures for the major lines of work were as follows:

| | |
|---|---|
| Management (Methods of cutting, natural reproduction and slash disposal) | $12,346.15 |
| Mensuration | 9,591.62 |
| Fire | 5,934.23 |
| Forestation | 1,048.00 |
| Forest Survey | 30,000.00 |
| Total | $58.920.00 |

Articles, Publications, Manuscript Reports and Addresses
Prepared by the Experiment Station Staff
From March 1, 1930 to March 1, 1931
And Proposed for 1931

## L. A. Isaac

### Prepared or Published in 1930

Survival of Seed Trees in the Douglas fir Region (Manuscript)

Northwest Scene of Active Planting. West Coast Lumberman, May 1930.

Seedling Mortality and the Restocking of Douglas fir Logged-off Land. Annual Cruise - O.S.C. Forest School 1930.

Seed Flight in the Douglas fir Region - Journal of Forestry.

Pacific Coast Pulp Wood Costs. In joint authorship with W. H. Gibbons. (Manuscript.)

Direct Seeding in the Fog Belt. (Manuscript).

### Proposed for 1931

Influence of Physical Factors on Establishment of Douglas fir Natural Reproduction. Approximately 50 ms. double spaced pages for Journal of Agricultural Research.

Device for Shaking Down Goose-neck Type Soil Thermometer. (For Ecology.)

Rates of Natural Restocking on Twenty Different Areas in Washington and Oregon - (For a technical journal).

## E. L. Kolbe

### Prepared or Published in 1930

Phinology as an Instrument of Forest Administration. Address for Northwest Scientific Association. December 1930.

Check List of the Conifers Likely to Survive in the Mild Localities of the Pacific Northwest. (Manuscript).

Phenological Observations in the Douglas fir Region. 1930 Progress Report (Manuscript).

Regional Races of Western Yellow Pine. 1930 Progress Report for 6 plantations (Manuscript).

Proposed for 1931

A Comparison of Several Geographical Forms of Douglas Fir in the Pacific Northwest. A summary of the results obtained from the analysis of growth data on five plantations. (In joint authorship with Thornton T. Munger). (For Journal of Agricultural Research.) Estimated 50 ms. pages double spaced with about a dozen tables.

Fifteen Years Growth Following Experimental Cutting on Three Plots in Western Yellow Pine. (For Journal of Agricultural Research or Journal of Forestry) Estimated 35 ms. pages double spaced with about 20 large tables and charts.

The Objectives of Marking Practice and how to Accomplish Them in Western Yellow Pine. (For Journal of Forestry).

Five Years of Phenological Observations in the Pacific Northwest. (For Ecology).

The Application of Mill Scale Study to Actual Stands as a Basis for the Comparison of Several Methods of Cutting in the Western Yellow Pine from an Economic Standpoint. (For a trade journal).

R. E. McArdle

Prepared or Published in 1930

The Relation of Mycorrhizae to Coniferous Tree Seedlings. For Journal of Agricultural Research.

The Yield of Douglas fir in the Pacific Northwest. U. S. D. A. Bulletin 201 T. Joint authorship with W. H. Meyer.

Effect of Fire on Douglas Fir Slash. Journal of Forestry, April 1930.

Working Plan for Hour Control Study. An explanation of our reasons for changing the (Tentative) standard procedure for analyzing fire records and for derivation from control standards. (Manuscript).

Proposed for 1931

Progress Report on Douglas Fir Slash Disposal Study. 60 ms. pages including approximately 10 charts. (For Journal of Agricultural Research).

Progress Report on Fire Behavior Study. About 30 ms. pages including 5 or 6 charts. (For Journal of Agricultural Research).

R. E. McArdle (Continued)

Statistical Analysis of Lightning Storm Reports. About 40 ms. pages. (For Monthly Weather Review).

Analysis of the Time Factors in Fire Control. (With Office of Fire Control). About 50 ms. pages with an additional 20 to 30 pages of charts. (For Journal of Agricultural Research).

W. H. Meyer

Prepared or Published in 1930

Volume Tables and Volume Alinement Charts for Western Yellow Pine on Sites II, III, IV, V and VI. (Mimeographed)

Thinning Experiments in Young Douglas Fir. (For Journal of Forestry).

Report on the 1929 Measurements of Permanent Sample Plots 2, 4, 5 and 9 on Columbia National Forest (Manuscript).

First Report on the Rainier Permanent Sample plots in Second Growth Douglas Fir (Manuscript).

First Report on Permanent Sample Plots 10, 11, 12. Columbia National Forest.

The Effect of Dry Cycles upon Forests and Some Forest Uses; Address for Northwest Scientific Association. December 1930.

Methods of Constructing Growth Tables for Selectively Cut Stands of Western Yellow Pine. Journal of Forestry, December 1930.

A Study of the Relation Between Actual and Normal Yields of Immature Douglas Fir Forests. Journal of Agricultural Research, Volume 41, No. 9.

Diameter Distribution Series in Even-aged Forest Stands. Yale University Bulletin 28.

The Yield of Douglas Fir in the Pacific Northwest, U. S. Department of Agriculture Bulletin 201 T. Joint authorship with R. E. McArdle.

Proposed for 1931

Report on the 1930 Re-measurements of the Cascade Permanent Sample Plots in Second-growth Douglas fir. (For a technical journal).

Effect of Release upon the Form and Volume of Western Yellow Pine. (For Journal of Forestry).

W. H. Meyer (Continued)

Report on the Growth and Yields of Selectively Cut Western Yellow Pine in Oregon and Washington. (Mimeographed circular).

Cyclic Variations in the Diameter Growth Rate of Mature Western Yellow Pine in Oregon and Washington. (For a trade journal).

Thornton T. Munger

Prepared or Published in 1930

Inventorying Oregon's Forest Wealth.
Oregon Banking Bulletin, March 1930.

Ecological Aspects of the Transition from Old Forests to New.
Address before American Association for the Advancement of Science, June 1930, Published in Science - October 3, 1930.

Firebreaks and Intensive Protection vs. Brush Piling in Pine Regions - Paper for meeting of Western Forestry and Conservation Association.

The National Survey of Forest Resources now in Progress in the Douglas Fir Region. Paper for Washington State Forestry Conference, December 1930.

Slash Disposal in the Western Yellow Pine Forests of Oregon and Washington. U. S. D. A. Misc. Publication.

Proposed for 1931

A Comparison of Several Geographical Forms of Douglas Fir in the Pacific Northwest. A summary of the results obtained from the analysis of growth data on five plantations. (For Journal of Agricultural Research). Estimated 50 ms. pages double spaced, with about a dozen large tables. (In joint authorship with E. L. Kolbe.)

The Wind River Arboretum - A progress report giving the growth and survival of the conifers, both native and foreign, tested in the arboretum at the Wind River Branch Station. (For technical journal).

H. B. Shepard

Prepared or Published in 1930

Working Plan of Forest Insurance Study in the Douglas Fir Region. Parts I and II.
General Prospectus
Detailed Working Plan for Phase One.

## H. B. Shepard (Continued)

The New Forest Insurance Study - Address for Forest Management Conference of the Western Forestry and Conservation Association.

## A. G. Simson

Prepared or Published in 1930

Relative Humidity and Short-Period Fluctuations in the Moisture Contents of Certain Forest Fuels. Address for American Meteorological Society. Published in Monthly Weather Review, September 1930.

Speaking of Humidity.
Four L Lumber News. June 1930.

Climatological Data 1911-1930 Wind River Station, Washington. January 1931. (Mimeographed).

The Effect of Relative Humidity on Short-Period Fluctuations In Fuel Moisture Content (Manuscript)

Note on the Effect of a Lightning Bolt.
Monthly Weather Review, November 1930.

The Effect of Atmospheric Humidity on the Moisture Content of Forest Materials. Manuscript for Journal of Agricultural Research.

Proposed for 1931

The Local Prediction of Thunderstorms.
(For a trade journal).

Zones of Thunderstorm Origin - 2 charts and 15 ms. pages.
(For Monthly Weather Review).

## H. J. Andrews

Prepared or Published in 1930

The General Plans for the Survey of the Forest Resources in the Pacific Northwest. Address for Portland Chamber of Commerce. 1930.

Cutover Land Problems in the Lake States. Address for meeting of Western Forestry and Conservation Association.

The Problem of Abandoned Cutover Lands. Address for meeting of the Washington State Forestry Conference.

H. J. Andrews (Continued)

The Forest Survey in the Pacific Northwest. Address before the Northern Rocky Mountain Section of the Society of American Foresters. February 1931.

Elements Essential to the Inventorying of Forest Lands. Address to the Student Body of the Forest School at the University of Idaho, Moscow, Idaho, February 1931.

Proposed for 1931

Methods and Problems of Technic in Making the Forest Survey in the Douglas fir Region. About 30 pages double spaced. (For a technical journal)

W. H. Bolles

Prepared or Published in 1930

Electric Portable Sawmills.
The Timberman, January 1931.

Forest Survey Staff

Prepared or Published in 1930.

Instructions for Preparation of the 1930 Timber Inventory of the National Forests. Douglas Fir Region. Region Six. (ms.)

Instructions for the Inventory Phase of the Forest Survey of the Douglas Fir Region for Lands other than National Forests.(Ms).

Instructions to Check Cruisers. (Ms.)

Working Plan for Making a Forest Inventory of Lewis County, Washington by the Linear Method of Strips Three Miles Apart. (Ms.).

Facts About the Forest Survey of the Douglas Fir Region. July 29, 1930.

Reports by Forest Survey Field Examiners have been made for Benton, Clatsop, Columbia, Cowlitz, Marion, Polk, Tillamook, Yamhill and Washington Counties.

## INVESTIGATIONS

### Forestation - Seed Studies

Regional Races of Western Yellow Pine - In the spring of 1928, over 32,000 trees, grown from seed collected in ten localities in the natural range of western yellow pine, were set out on six areas in Washington and Oregon, to test and compare their survival and adaptability to various sites. These plantations are located on three national forests and on the demonstration areas of the three local forest schools. They are examined each fall for survival and growth. During 1930 (the third season) the mortality for all plots averaged nearly 8 per cent. As expected, the plantations west of the Cascades have a much better survival and growth than similar plots in the dry pine type east of the mountains. No analysis of the annual data to determine adaptability and hereditary characteristics will be made until the plants are well established and larger in size.

Douglas Fir Heredity Study - These plantations did not come up for examination in 1930. The experiment was started in 1913 and there are now in the files ten sets of periodic measurements for the five plantations. These have been organized for analysis and it is interesting to note that they comprise over 180,000 recorded observations. The next triennial examination of these plots will be made this fall. A progress report for publication is to be prepared during the coming year.

Seed Studies - The second run of the cold storage method of holding noble fir seed is now in progress and annual germination tests from the lots of seeds now in storage will be made. The study will continue one year more. Results obtained to date are already being used, as all Abies seed is now being held in cold storage in Region 6.

Forestation - Nursery Practice

Very satisfactory progress was made in nursery investigations during the year. Work was confined entirely to phases previously undertaken and no new studies were initiated. Of special interest was the study concerned with the production of a satisfactory grade of Douglas fir planting stock of seedling age to use in place of standard transplants and the study of damping-off control.

In the former, ten new plots of 2-0 seedlings grown at densities of 40, 80 and 120 per sq. ft. in the seedbeds were set out together with standard transplant stock on three Forests to determine their comparative survival and growth. In addition, new lots were started in the nursery to continue the field tests in latter years. To date a total of 38 tests have been made of various grades of seedlings varying in seedbed density from 40 to 160 per sq. ft. These are distributed among 17 separate plots on a wide variety of sites in the Douglas fir region. All tests have been with stock from low altitude seed, sown in the fall. Before the study is completed, it is planned to include spring sown stock from low altitude seed and both fall and spring sown from high altitude seed. Notwithstanding the wide variety of the sites on which the test plots have been established, results have been remarkably consistent. First year survival in each class averaged for all plots irrespective of location and character of site has been as follows:

| | |
|---|---|
| 1-1 transplants | 90% |
| "40" seedlings | 85% |
| "80" " | 79% |
| "120" " | 75% |
| "160" " | 48% |

It is very evident from these figures that the density under which the trees are grown in the seedbeds has an important influence on their value as planting stock.

The study in control of damping-off at the nursery consisted of a second series of tests with various chemicals, designed as a check on the elaborate tests made the year before. Results were largely corroborative of the latter, and indicate the effectiveness of either sulphuric acid at the rate of 1/4 oz. per sq. ft. or aluminum sulphate at 1 oz. Besides checking damping-off losses, these chemicals also reduce the quantity of weeds materially.

A third and relatively minor phase of nursery investigations concerns the determination of the correct technique for the production of species other than Douglas fir at the Wind River nursery. The method employed is to make small initial sowings of various species followed by subsequent trials with such variations in technique as previous experience indicates desirable. Twenty-four such tests embracing 20 different species were in progress during the year, of which five were new installations. Seven were completed.

Forestation - Field Planting and Seeding

All investigations in field planting and seeding, with the exception of two phases handled by the Experiment Station, are conducted by local Forest officers under the general direction of the Section of Planting and usually in accordance with working plans prepared by the latter. Four phases relating to Douglas fir and four to other species were in progress during 1930.

In the Douglas fir spacing study in which plantations were established by the Experiment Station on the Columbia National Forest illustrating various densities of spacing ranging from 4x4 to 12x12,

fail places were again planted and the fifth year height measurements made. A new plot to study the effect of brush on Douglas fir survival was established on the Columbia National Forest making a total of five plots or series of plots thus far installed for this purpose. Two series on the Rainier National Forest were given their scheduled examinations. Thus far these have shown no particular increase in mortality attributable to brush. A new plot was also established on the Olympic National Forest to study the occurrence of rodent cropping in young Douglas fir plantations and the effect on survival of its continued repetition. A similar plot established previously on the Rainier National Forest and which had shown pronounced diminution in the amount of damage the second year, again exhibited very little cropping the third year. Plots on different sites on the Rainier National Forest comparing fall and spring planting at high altitudes were given their third year examination. These show a mortality of 40 and 13% in fall planting in contrast to 34 and 1% in adjacent spring plots, the latter being superior in survival on both sites.

Of the studies in planting and seeding with species other than Douglas fir, the tests of direct seeding with small seeded species such as western red cedar, Sitka spruce and western hemlock which have been conducted by the Experiment Station in the fog belt region on the Olympic Forest in Cooperation with local Forest officers for a number of years are yielding some very interesting results. Second year survival in the original sowing ranges from 377 Sitka spruce seedlings to 1585 western hemlock seedlings per acre per pound of seed sown, and first year survival in the second series from 178 Sitka spruce to 288 western hemlock. These results are quite encouraging

from the standpoint of survival and if seed costs can be reduced to a more reasonable figure than now prevails, it appears that this method of reforestation holds considerable promise of successful use.

Two of the three series of test plantings of noble fir on a variety of sites installed on the Rainier and Mt. Hood Forests and one series with silver fir received their scheduled examinations during the year. Results to date are not greatly different from those disclosed in previous examinations; namely, that both species show a decided preference during their early years for the cooler northerly slopes.

In the study of the suitability of alder for the formation of fire breaks on snag-free, logged-off areas, lack of trees prevented the installation of any new plantings, but additional stock was grown at the nursery for 1931 planting. The one break previously planted on the Olympic Forest in 1928 has made encouraging growth. Further tests are needed to determine the limitations of this species on the dryer situations such as would be encountered in any systematic arrangement of fire breaks on an extensive scale.

In the study of planting requirements of western yellow pine, a new series of plots were started on the Umpqua Forest to compare fall and spring planting and the effect of various densities of brush. Plots on the Crater National Forest, established in 1929 to test the influence of overhead shade on survival and growth were given their second year examination. Thus far the advantage of such shade on initial survival is rather striking.

Forestation - Test of Exotic Species

This line of investigations has a two-fold object - the establishment of an arboretum at the Wind River Branch Station and the

determination of the suitability of various exotic species for growth under forest conditions in different sections of the region, and the extension of the range of certain valuable native species of limited natural occurrence. Several new additions were made to the arboretum as well as to the species being propagated in the nursery for later planting. Arrangements were made also for the acquisition of South American species of which there is now only one representative in the arboretum. One new demonstration plot of bigtree was installed on the Olympic National Forest and one of Port Orford cedar on the Siuslaw National Forest. Several previously established plots were given their periodic examination. All plots of Port Orford cedar located in the coast region some distance north of its natural range continued to show good survival and fair rate of growth. One located in the Cascade region has done poorly, largely because of gopher injury. Bigtree in the Cascade and Olympic region has given only fair survival and hardly normal growth. Redwood plantations continue to struggle along with almost annual recurrent frost injury at all elevations except sea level. Monterey pine in the coast region has done well on good soils but poorly on sterile sands. Scotch pine and Norway pine on rather severe sites in the yellow pine region have been failures.

Forest Influences

The Committee considered erosion streamflow studies of high importance, though no work of that nature is under way in the region and practically none has been done in the past. In later pages of this report recommendation is made that this region be alloted specific funds in the fiscal year 1933 and thereafter for a program of basic studies in erosion control and streamflow regulation, particularly

as related to forest management, range management, and forest protection. Pending the allotment of special funds for streamflow-erosion studies, it was recommended that some preliminary work be done this coming year in the most pressing of these problems, namely, Erosion and Streamflow Control on the Wenatchee Forest and contiguous territory in central Washington where the water users are very much concerned over the maintenance of maximum run-off from the forest areas. This project is listed as a new project for 1931. See also the "Program for Research and Range Management" of this report.

Management - Slash Disposal

The proper disposal of logging slash in the Douglas fir region continues to be a most important technical problem. In formulating the basic principles to assist in determining how any particular type of cut-over area should be treated to obtain minimum present and future fire hazard and prompt reforestation, the study brings together all pertinent information gathered by other agencies and also involves exhaustive independent investigations. The independent studies falls in two major lines of attack: periodic examination of a series of permanently marked sample plots strategically located in typical slash areas, and historical studies of a large number of slash areas for which the complete fire history is known. There are now 58 permanent sample plots for which 132 examinations or remeasurements have been made; on some plots for the fourth time. During the past field season, 9 new plots were established, 26 of the older plots were reexamined, and 6 remeasured to learn the amount of material removed by fire. Historical records were obtained for 28 typical slash areas. Measurements were made of the moisture content of unburned slash materials under different types of cover on adjoining areas in an

attempt to rate the fire hazard of these areas. More intensive studies were made in various localities to determine the effect of various types of cover in retarding the drying of woody fuels and to learn the effect of rain and relative humidity in changing the moisture content of these fuels. These studies showed rather definitely that the effect of a light summer rain is entirely lost within about two days unless the rain is followed by cloudy weather with very high humidity. Nearly all computations for the slash disposal study are completed to date and now await preliminary summarizing and detailed analysis. The study has been in progress for too short a time to justify making definite conclusions concerning this very controversial subject.

The study of slash disposal in yellow pine was concluded by the preparation of a manuscript covering the results of the study; it was edited for publication this year and should be issued in the near future. Tests of swamper burning continue as administrative studies.

Management - Methods of Cutting

Four areas on the Malheur Forest, comprising 35 acres, were added this past season to the series of permanent sample plots to test various methods of cutting in the western yellow pine type. The total number of plots is now 21, with an area of 278 acres. The plots range from 5 to 50 acres in size and are located on four national forests in eastern Oregon. All plots are examined at least once each year; those on which more intensive reproduction studies are carried on are gone over two or three times during the growing season. These plots are designed to test the results of various styles of selection cutting upon quantity and quality of growth,

upon reproduction, and upon the financial aspects of timber management. During the coming year the results of the two mill scale studies in the region will be applied to the data regarding stands and volume conditions at various periods on a number of plots and progress reports now under way will be completed. In the field the examinations will be continued as in the past, but no expansion in the number of plots is proposed for the coming year. The establishment of experimental forests in the pine region east of the Cascades in Oregon will be especially important in long-time studies such as these that serve a manifold purpose.

Management - Natural Reproduction of Douglas Fir

With the rapidly increasing acreage of logging in both old growth and second growth and the unsatisfactory condition in which much of it is left, the reproduction study of Douglas fir continues to stand out as one of the Station's major projects. Headings under which various phases of the project are being studied are as follows:

1. Seed survival
2. Seed dissemination
3. Germination and survival on different sites
4. Measurement of physical and biological factors that influence seedling establishment
5. Seed tree survival
6. Grazing and reproduction on Douglas fir cut-over lands

The above phases of the study are covered in detail on a combined project sheet and will be continued with minor changes in 1931.

The study of germination and seed loss under timber is nearing completion and the third series of tests in duff storage of seed was started in the fall of 1930. The seed dissemination study is being combined with germination and survival plots on different sites in order that the seed traps may give, in addition to distance

of dissemination, a measure of seed fall on the sample plots. The germination and survival study was extended by the addition of three groups of sample plots on fresh burns and one group in the fog belt type. The germination that will result from the heavy seed crop of 1930 will help to tell the complete story on many of these plots in another year. The measurement of factors (physical and biological) study in the Wind River Valley has furnished some important information. During 1930 frost injury and the consumption of seedlings by mice was added to heat injury and drouth as major causes of seedling loss, any one of which might claim a large part of the annual seedling crop. This study now conducted on a level area should be checked on different exposures and different sites. The "single seed tree" survival studies that have previously shown a mortality of 46 per cent and an uncertain value for reseeding purposes, have been extended to include the group system of leaving seed trees and will in all probability be correlated with the proposed economic area selection cutting as sale conditions permit.

The natural reproduction study as a whole to date brings out certain definite points that may be summed up as follows:

1. The life of seed after it falls is short, probably not more than a year.

2. The distance of seed dissemination, while it might reach almost unbelievable proportions under certain conditions, is in general under 1000 feet.

3. There is a heavy loss of both seed and seedlings by bird and rodent consumption and by seed decay and seedling death.

4. Slash burning appears to retard restocking first by destroying seed and living trees on the ground and second by making the site more severe through blackening the surface and by consuming the duff and humus and dead shade.

5. Seedling establishment in general is proportional to the severity of the site and the seed supply and varies with the distance from the source of seed.

6. On 6 sample areas the average loss of single seed trees was found to be 46 per cent and the value of single seed trees as a source of seed appears questionable.

7. A surplus of seed, over and above rodent consumption and decay, and a survival of seedlings sufficient to result in good restocking has followed on many areas where there was a goodly seed supply, the site was not too severe and fire was kept out.

Since seed life is short, the distance of dissemination not great, and losses of seedlings are heavy, it is evident that less severe site conditions and more adequate seed supply and fire protection are needed; where they exist there are plenty of examples of good restocking. Opportunities that present themselves to aid in securing the desired results are (a) to conserve seed and seedlings and make site conditions less severe through less burning (both in acreage and severity) on areas of low fire hazard, and (b) to provide a more ample seed supply and more adequate fire protection through breaking up cut-over areas by leaving strips or blocks of green timber; in other words, correlating reproduction studies with slash disposal, the present system of leaving seed trees and the proposed economic area selection cutting.

Management - Silvicultural and Economic Aspects of Tree Selection Cutting in Douglas Fir.

Mr. Hanzlik proposed that a study be made of selection cutting in second growth Douglas fir as a means primarily of aiding the private owners who are cutting heavily in this kind of timber toward better forest management. The committee was unanimous in agreeing that the project was very important but there was no prospect of undertaking it this current year. It is accordingly proposed as one of the projects for which an additional allotment should be sought for the fiscal year 1933.

Management - Thinning Sapling Stands of Western Yellow Pine.

The Committee recommends that this study, which has been carried on as a minor project for several years, be now designated as a major project sub-assigned to the several forests. By doing this, the program will place thinning in western yellow pine on a par with thinning in Douglas fir.

Management - Thinnings in Douglas Fir

Mention of this project is made below under "Permanent Sample Plots in the Douglas Fir Region". No work was done on this project this year.

Mensuration - Growth and Yield of Western Yellow Pine.

With the three years of field work completed, the office work is now progressing rapidly. Sufficient detailed description was made while gathering the data so that the analysis can proceed upon a single tree basis or upon an area basis. For the time being the area basis is stressed since much confidence is felt that the greatest factor in the rate of growth of reserve stands is the volume left per acre, modified somewhat by the character of the stand, such as the percentage of trees in the different age classes. Later on this analysis will be checked by an individual tree study.

Complete stem analyses of felled trees have led to the tentative conclusion that although there is a decided change in the form of the individual trees after cutting, nevertheless when taken in the aggregate the final result is balanced so that a volume table will apply equally as well to the stand at the time of cutting as any number of years thereafter.

Through the kind cooperation of the Idaho School of Forestry, it is planned to combine their data on yeild of evenaged fully- stocked

stands of second-growth western yellow pine with ours and thus with more than double the amount of data prepare yield tables which will apply to Oregon, Washington and Idaho.

Since the 8000 borings taken in the yield study of selectively cut stands have been preserved, there is ample opportunity to make a thorough examination of the diameter growth variation through the past centuries in order to determine whether the present period of poor growth is exceptional or whether it is a factor which should remain uncorrected because it reoccurs periodically throughout the life cycle of the stand.

Mensuration - Permanent Sample Plots in the Douglas Fir Region.

Thirty-six plots are being maintained in second-growth Douglas fir and two plots in spruce-hemlock. In addition, the Station maintains or cooperates in at least ten other plots established for the purpose of studying the effects of thinning in Douglas fir. In 1930, three plots in an unthinned stand on the Cascade National Forest were measured for the fifth time over a period of twenty years. During this period the board-foot volume has increased 78 per cent while the number of trees over 12 inches D.B.H. has increased only from 111 to 118. Three new plots were established on the Mt. Hood National Forest which show the effect of stocking upon the form of trees in a 40-year-old stand of Douglas fir.

Mensuration - Volume Tables

Responding to the long felt need for a set of site-class volume tables for western yellow pine which would apply to its entire range and supplement those issued by the Washington office in 1927, the Station has compiled a complete set of tables covering board-foot

volume based upon total height and merchantable height and total cubic-foot volume using the same basic data. A folder containing all three sets of tables for Sites II to VI together with five alinement charts was sent out in limited distribution.

At the 1929 Investigative Meeting definite plans were laid to do some work on Douglas fir volume tables expecially in regard to large sizes. This work was postponed temporarily pending the action of the Washington Office in the preparation of new site-class volume tables for this species. As soon as these appear they will be applied and tested to the timber of the Pacific Northwest.

Mensuration - Quality Yield Studies.

Mr. Munger laid before the Committee the striking need for quality yield studies in combination with quantity studies. Much stress is being placed at the present time upon the actual quality of the wood as evidenced chiefly by the grain or number of rings per inch. Sooner or later a study of this nature will have to be made, so that the recently completed Douglas fir yeild study might be interpreted in terms of value and price as well as quantity increment. The Madison Laboratory has already made some indicative studies which we hope will be continued and expanded. The proposed mill scale studies of Douglas fir will take account of the rate of growth in relation to lumber grades.

Mensuration - Spruce-Hemlock Yields.

There is a rapidly growing demand for information regarding this important forest type. However, with the office phases of the western yellow pine yield study still incomplete and with the temporary assignment of Meyer to the growth phase of the Forest Survey,

there are neither funds nor personnel available for the attach of this important problem in the coming year. It is therefore not entered on the program though recognized as the next most urgent mensurational project.

Protection - Fire Studies

In view of the $15,000 increase for fire studies, the Committee devoted considerable time to a discussion of the existing program of fire studies. It was decided that it would be better to place more emphasis on completion of present studies than to undertake many new studies at this time. Consequently only two of the more urgent fire problems were proposed for new projects to begin in the fiscal year 1931.

Protection - Weather and Fuel Relationships

In the study of weather and fuel relationships centered at the Wind River Branch station, measurements of the moisture content of green bracken fern, dead bracken fern, green fireweed, Douglas fir needles, and Douglas fir duff were again made at 10-day intervals throughout the fire season to obtain the seasonal change in fuel moisture content. The diurnal change in fuel moisture content was reported last year. The past season ended 20 years of weather observations at the Wind River station and summaries of these observations were made for distribution to those likely to use such data. The effect of cover and altitude on relative humidity was studied again this year but the data is not entirely analyzed at this time. It was decided by the Committee that work as a separate project should be ended and a report written summarizing the results so far obtained at Wind River. This project will be closed although further work should be done in the region under some other fire studies project.

Protection - Static as an Indicator of Fire Weather

The season's results in using static as an indicator of lightning storms were encouraging. Five small static meters were in operation at the dispatchers' offices on the Chelan, Mt. Hood, Whitman, Deschutes and Fremont Forests. It was expected that this first season would be useful chiefly in testing the instruments and their locations. As a result of these tests it was found necessary to replace certain equipment used in constructing the meters; on some forests there is too much local interference at the dispatcher's office to use the meters successfully there. It was considered desirable to make the necessary minor changes in instrumental design and to continue the study another year.

Protection - Reporting and Charting Lightning Storms

This has been a major study since 1924, and a mass of data has been accumulated through the cooperation of more than a hundred lookouts scattered over the national forests of this region. The origins of the individual storms have been plotted on forest maps, disclosing in some instances rather well-defined breeding grounds for thunderstorms. The movement of the individual storms also is plotted on maps to find if there are definite lightning storm zones and normal paths of storm movement. The data contained on the reports also have been transferred to punch cards for statistical analysis. Time has not been available thus far to analyze the maps of all the forests nor to write up the reports. Doubt was expressed as to the value of the statistical analyses and the entire project but the majority favored carrying the project on as contemplated on account of its nation wide character. Mr. Pagter said that he did not believe the study was troublesome to the forests, but thought it would be

advisable to publish at least some preliminary findings as soon as possible. Mr. Buck accordingly asked that the lightning storm data be analyzed this year. Mr. Brundage expressed the hope that this could be done, but not at the expense of carrying on the other fire studies as planned.

Mr. Dague of the Weather Bureau explained that the present data were too voluminous for him to use in checking thunderstorm occurrence with predictions. Instead he was using map reports of the occurrence of each lightning storm sent currently by the dispatchers. Mr. Dague also stated that information was needed both on storms that start fires and those that do not, and on the topography of the country where storms originate, particularly as to the aspect of the slopes over which storms form.

In discussing the need of forest agencies for more summarized analyses of the weather factors of fire hazard, Mr. Munger said that he wished the Weather Bureau might make studies of the relative climatic fire hazard of various regions in the two states. This would recognize the individual elements of hazard such as relative humidity frequency, precipitation, probability of high winds, probability of lightning, storms, etc. He said that he thought this should be done in two ways, first, seasonal rating to bring out the relative fire danger of various regions on account of their whole seasonal climate, useful for such purposes as insurance rating, for example, and second, a rating by 10-day periods to show for each region the length and progress of the fire season so far as it is controlled by climate. Mr. Dague said that this matter was one which would be discussed by the Weather Bureau officials at their meeting in Spokane this month.

Protection - Fire Behavior

Due to the favorable season, very few large fires were available for the study of going fires. Four fires of moderate size were studied and no change was found necessary in the new technic for this study reported on last year.

Protection - Equipment for Fire Line Construction.

From 1927 to 1930, a number of tests have been made under the supervision of the Office of Fire Control with various kinds of tractor and horse-drawn plows, scrapers, and harrows for fire-line construction. Of the heavy equipment used, the Killefer plow with the No. 15 caterpillar tractor gave the most satisfactory results. A small 9-horsepower Vaughan tractor and plow, total weight 760 pounds, gave good results in certain open yellow pine types. A new piece of equipment which was tried out under a variety of east side and west side conditions pulverizes the soil on a 20-inch swath for a depth of from 4 to 8 inches. Several tests of horse-drawn plows were made primarily to stimulate a more general use of such equipment under a wider range of conditions.

A large amount of experimental work has been done in developing portable snag-boring equipment to facilitate the falling of snags with powder. As a result of these experiments, the Westinghouse Electric Company, with specifications prepared by C.M. Allen, made a portable gas-electric power plant weighing 118 pounds and easily divisible into two units of about 60 pounds each. The plant furnishes ample power to operate through 500-foot cables two electric drills boring 1-1/8-inch holes in sound Douglas fir snags with an average boring speed of from 40 to 50 inches per minute. On a clear-

ing project about 1400 snags were felled with this equipment in much less time and at less cost than with saws.

During the year there were no important developments in the studies of lights for night work and in tests of torches for back-firing. Current use of the equipment reported on at the last meeting confirmed the findings of last year's tests.

Protection - Analysis of Time Factors in Fire Control

A new study begun since the last meeting of the Investigative Committee is an analysis of the time factors in fire control. The purpose of this study is to indicate, by analysis of fire reports, an adequate basis for determining the speed-of-attack necessary in order to hold the burned acreage to certain previously defined objectives. The time factors involved are those of discovery, report, get-away, and travel times. The study was begun with one forest as a unit to work out the details of technic. The working plan prepared as a result of these preliminary studies is proving to be satisfactory. This study does not replace another one originally considered which will analyze all items on the fire reports; but at the request of the Regional Forester the present study is given priority because the information resulting from the study is so urgently needed. Analyses for the Umatilla, Malheur, Ochoco, Fremont, and Chelan Forests are completed; those for the Wenatchee and Colville Forests are nearly completed. After completion of analyses for the Wallowa, Whitman, Deschutes, and for the east side of the Rainier, the data for certain groups of these east-side Forests will be combined as, for example, the Oregon forests in the Blue Mountain group. It is planned to extend this project, with similar analyses, to the west-side forests next fall.

Protection - Fire Damage

This subject came in for considerable discussion and it was decided to begin work on this project. This basic information on the kind and amount of damage ordinarily caused by forest fires will make possible the rating of fire hazard in different types and will enable more accurate measurements of the effects of forest fires. A small amount of work in fire damage has been done in this region, chiefly in connection with the forest insurance study and in a minor study on a few forests to determine the effect of slash fires on seed trees. Much of this work is of the physical survey type and may prove to be too general for a thorough study of fire damage. It was decided that this work should begin in southwestern Oregon, especially in Douglas county where light burning is practiced, since information is now urgently needed in this part of the region on the effect of fires on soil, timber production, grazing and permanent land use.

Botanical Studies - Phenology

Observation stations are now located on each national forest west of the Cascade, on the Peavy Arboretum of O. S. C., on the Pack Demonstration Forest of the University of Washington, on Seattle's Cedar River Watershed, and in the Portland Civic Arboretum. The addition of the last named in the spring of 1930 brought the total number of stations up to 23. On these plots during the year 1930, a total of 2403 events were recorded for 27 species of plants. Noteworthy progress was made in obtaining more accurate records. No change recommended in the conduct of this project in 1931.

Forest Economics - Forest Survey of the Douglas Fir Region

The Forest Survey has been under way just a little over one year. In that time working plans for all aspects of the inventory phase of

the project have been drawn up, and about 40 per cent of the field work has been completed. Working plans for the growth, depletion, and requirements phases are as still at the formative stage as was the inventory phase a year ago.

Work on the inventory divides itself into two major subheads, namely, procedure on national forest land, and procedure on all other lands. On the national forests, existing data, aside from that for the areas which have been cruised intensively for timber sales, land exchanges, claims, etc., consists of the extensive reconnaissance made in 1912-1915 and revised in 1922-3. On these areas a plan for gathering both type and volume data by what might be called an intensive application of the reconnaissance method has been used, and to date field work has been completed on two national forests and is in various stages of progress on all the others, with a total of five million acres of national forest land covered. Present plans contemplate the completion of field work on the national forests by the end of the 1931 field season. Twelve men are employed on this work.

Work on private lands, O & C railroad grant lands, and other publicly owned lands resolved itself into four major phases.

1. Transcribing existing cruises, including the copying of private, O & C, and county cruises, and also the records of areas cut over.

2. Field Mapping and volume estimating for all areas not covered by existing cruises.

3. Adjusting of private, county, and O & C cruises to a common standard by the checking of sample areas in the field.

4. Assembly and recapitulation of all data obtained both from office records and by field work.

At this time practically all of the transcribing of existing data has been completed. Field mapping and volume determination has

been done for eight counties and is now in progress in four others with four men spending all of their time on it. Adjusting of cruises by field checking has been completed in six counties and is under way in three others with four men spending all of their time on this work. Compilation procedure has been completed for one county and working plans for standardizing this procedure are under way. Progress was illustrated by a large-scale map of the region.

If work continues at the present rate of progress, and if appropriations are as large next year as this, it is expected that the bulk of the field work on lands outside of the national forests could be completed late in the winter of 1931-32.

The base map of Oregon, upon which the forest cover type map will be printed in colors, is well under way and should be completed by spring; the base map of Washington has just been started. The drafting and publication of these maps is being financed wholly by several cooperating state agencies. Since these base maps, which are on a scale of 1/4 inch to the mile, cannot be expected to show all the forest cover detail which the field men have obtained, it is the hope that funds may permit of producing a limited number of maps for each county on a larger scale for the detailed use of the State Foresters, wardens, and other interested agencies. It was explained at the Investigative meeting that these maps are being sent to various agencies for checking and the question was raised whether there were further means of making them as nearly correct as possible. It was decided that proofs of the maps should be sent around the Regional Office.

The cooperation of the State Foresters and their staffs and of the timberland owners has been very cordial and exceedingly useful.

Without it the project could not have progressed as rapidly and as successfully as it has. State wardens have this winter been acting as assistants to the check cruisers in both States. Private owners have been, with few exceptions, willing to allow the confidential use of their cruises.

In order to test out for a county or two the methodology of linear strip surveys in this region and to make a comparison of that method with the compilation method, a crew of three has been assigned to Lewis County which will be covered with strips three miles apart. A detailed working plan for this method has been prepared. The committee questioned the need for this work, and asked how the superiority of either method could be judged in view of the unmeasurable and widely divergent character of the data gotten by each method. It is felt that the stripping method without mapping in place gave results of no value on the national forests.

Most of the work on the Forest Survey so far has been on the inventory phase, but plans are now being formulated for the other phases which are quite as puzzling in their technic, though not so time-consuming. The growth phase will be handled by Walter H. Meyer of the Experiment Station. The depletion phase will be done in cooperation with the Office of Forest Products, Bureau of Entomology, Bureau of Pathology, Office of Fire Control, and the State Foresters. The requirements phase will be handled in cooperation with the office of Forest Products under plans directed by the Washington Office. The Committee discussed at some length certain phases of the technic of the inventory. The question was raised whether snag areas were being typed, and it was brought out that it is being done by some men on the national forests and in the stripping of Lewis County. It was

left that snag areas would be mapped hereafter if the Office of Fire Control would supply definitions and a legend. The stocked quadrat method of mapping restocking was discussed and its advantages explained in answer to questions.

The Committee felt it highly desirable that the region east of the Cascades be covered by the same organization as soon as the Douglas fir region was completed, and passed the following formal resolution to that effect:

> " It is the sense of this Committee that it would be wise to commence work in the pine region of Oregon and Washington with the present organization and under the administration of this Region."

It was thought that it could be done in one long field season, but the Regional Forester thought it would make national forest contribution much easier if the job could be spread over two years.

Forest Economics - Forest Insurance in the Douglas Fir Region

The activity of the insurance study, in the direct research phase, has so far been directed toward determination of accurate rates. Since rates depend directly on hazard and since the best measure of hazard is past experience, this involves a study of the damage done by fires over a period of years.

For this study the fire records of the protective associations are available, and also those for the National Forests, though these latter, because of the essential differences prevailing between the National Forests and most of the privately owned lands, are mainly useful in indirect ways.

The data given in the association reports are not in such form that they can be used actuarially but even if they were other work would be required since the form in which the data are given is too ex-

tensive and the indications given are much too broad. If it were possible to apply rates averaging over a wide range of conditions it would not be necessary to go behind the fire reports to any great extent but the requirement for a rating system that adjusts the rate with relation to the relative hazard introduces the necessity for refinements that can only be made through a very considerable amount of supplementary work.

The two chief elements of this supplementary work are, 1;- field analyses of burned areas resulting from fires of over 200 acres in very recent years in ten selected counties in Oregon and Washington and 2;- the collection from the district wardens, through the medium of specially designed supplementary fire reports, of data on all fires of over 50 acres in the past five years in the whole region. It is anticipated that about 1500 fires will be covered by these reports and early returns indicate than an ample amount of data, factorable to show the influences of the variable hazard elements, will be made available.

Early efforts had to be directed toward the identification of the essential variable elements of hazard in the region. The "Suggested Schedule for Rating, etc." (printed below) which was used as a basis for discussion at the Committee meeting is the result of this work in that it is believed that it embodies substantially all of the hazard elements that will have to be recognized. The purpose of the statistical study of the material being gathered as described above is, of course, the determination of the relative values of these elements. Successive sortings and run-offs of the data will yield figures that can be integrated, first with data from each of

the various sources and second, with the final results of the Forest Survey. Not until the Survey figures become available can real dollar and cent values be put into the rating schedule.

Two independent studies must be undertaken and are now definitely planned for in detail. These are; a study of climate in its relation to the variation in hazard zonally, and; a study of protection for the purpose of grading the protection effort in the various districts.

With reference to the schedule it was suggested at the Committee meeting that administrative difficulties might easily be encountered in the application of the proposed system of rating by five major classes, particularly since a stand passes, as now proposed, from the lowest to the highest rating as it grows from 24 to 26 feet high. The suggestion was made that this difficulty could be avoided by the use of a rate curve which would effect a gradual transition from one class to another. No objection to such a method can be perceived and it is extremely likely that an adaptation of this principle will be adopted in the final schedule.

It was also suggested that the hazard from berry pickers is definitely ascertainable with respect to individual properties and that the hazard should therefore be made specific and not included in the basis rate as at present proposed. This question will be given special attention.

The question of the value, for insurance purposes, of immature growth is one of great importance. Of equal importance is the consideration that serious difficulties would be met if the attempt were made to insure stands of trees so small that they would be wholly consumed by an ordinary fire. Except in the case of artificial plantations it can probably be accepted as a fact that insurance can-

not be applied to stands averaging less than three feet in height, at least in the early stages of development.

The theory of credits is that they adjust the rate to properties having hazard conditions even better than those ordinarily considered the best. These conditions may be fortuitous or the result of the owner's deliberate effort to reduce hazard. For such results as may be expected from the owner's efforts credit is given in such manner that the total cost of the insurance and the effort is less than the cost of insurance alone would otherwise be. These credits are given in such a way that there is minimum danger that the elements for which they are given might be neutralized by an adverse attitude on the part of an abutting owner.

Following is given a tentative schedule for rating any individual property in the Douglas fir region, which recognizes the various elements that can be factored out:

A Suggested Schedule for Rating Forest Properties
in the Douglas Fir Region for Forest Fire Insurance

Forest properties to be graded in accordance with the following schedule of charges and credits for the determination of the annual rate which will include a dry season charge so adjusted that the annual premium will be absorbed during the so-called fire season. Policies will, however, cover for the full year.

The sole objective is the proper rating of individual properties wherever located by a specific rating method.

The system is based on the establishment of standards with charges for deficiencies (below standard conditions) and credits for extraordinary conditions which raise the property to "above standard" conditions. The standard is the least hazardous condition ordinarily prevailing.

The basis rate covers all the hazard elements that the property has in common with all other properties in the same geographical unit (county or group of counties i.e., the elements that cannot be analyzed or measured for one property unit as distinct from others near it. Beginning with the basis rate, differentiation is made by introducing into the schedule in logical sequence each known and measurable element peculiar to the individual risk itself.

BASIS RATE: (.....County) .....

(Determined by study of losses resulting only from hazards common in equal degree to all properties in a county; i.e. deficiency in public protection, deficiency in climate; hunter, berrypicker, incendiary, and conflagration hazards.)

KEY RATE: (..... Class) .....% ..... .....

A percent of the basis rate added as allowance for the variation in hazard due solely to the age class.

Five classes established, one of which is standard, taking no charge, as follows:

Class I - (No charge) - Stands mainly of trees 25' high to 6" DBH.

Class II - Stands mainly 6" DBH to 20" DBH.

Class III - Stands mainly 20" DBH to 40" DBH.

Class IV - Stands mainly over 40" DBH.

Class V - Stands mainly 3' to 25' high.

CHARGES (ADDITIONS)

(Percentages of the key rate) %

1. Area ..... Excess ..... .....

(Recognizing that the danger of loss is greater where value is concentrated than where an equal value is scattered.)

CAUSATIVE HAZARDS:

2. Property in recognized lightning zone .....

3. Exposed by common carrier steam railroad:
   Direct .....
   Indirect (R.R. within one mile) - .....

4. Fishing streams or lakes:
   Direct (On property) .....
   Within one mile .....

5. Land Clearing for Agriculture (Brush burning hazard):
   On property .....
   Within one mile .....

6. Lumbering:
   On property .....
   Within one mile .....
   Inadequate debris disposal .....

7. Habitual Camping: (or picnicking)
   On property .....
   Within one mile .....

8. Casual Camping or Picnicking: .....
   (Measured by distance from towns and cities, and accessibility)

Brought forward: .....

9. Hotels and resorts: .....
(Effecting an increase in the hazard from entry and use.)

CONTRIBUTIVE HAZARDS:

10. Brush land .....
Charge graded according to area and distance from insured growth.

11. Fern Areas - .....
Charge applied in same manner though probably on a different scale of values.

12. Snags .....
Charge according to acreage of snag area and distance away.

13. Unburned Slash .....
(Not accompanying a going logging operation, i.e., slash that has been abandoned.) Charge to be graded according to acreage and distance.

14. Grass and Weeds .....
Mainly recent cutovers which have not yet developed into other types of land. Charge graded according to acreage and distance.

15. Blowdowns .....
Probably to be treated like unburned slash

16. Hemlock, Spruce, Cedar, or true firs in the Stand .....
Charge graded according to percentage of these more damageable species in the insured stand.

17. Incomplete stocking .....
Charge graded according to deficiency in stocking on percentage basis because hazard varies inversely with stocking in almost all stands.

18. Unfavorable Topography .....
Charge graded according to the percentage of insured timber located on slopes steeper than a selected standard, probably 40%.

19. Dead or Dying Timber (Not snags) .....
(From disease, insects, or previous fire)
Charge graded according to amount.

20. Deficient water supply (Streams, lakes, etc.) .....
Charge made here grading of public protection included a credit for portable pumps.

Brought forward .....

GROSS RATE: .....

CREDITS (DEDUCTIONS)
(Percentages of the Gross Rate)

1. Exposure Breaks: %

   a. Fully stocked stand of Douglas fir second growth between insured stand and surrounding hazards (25' high to 6" DBH) ..... .....
   Credit graded according to width of this strip of fire resistive growth and percentage of perimeter protected.

   b. Rivers over standard width .....
   Credit graded according to percentage of perimeter protected.

   c. Lakes .....
   Same as rivers.

   d. Cultivated Fields (Not grass or grain) .....
   Credit graded according to width and percentage of perimeter protected.

2. Private Protection (Above legal)

   a. Privately maintained patrolmen (requirement) .....
   Owners of large properties may support patrolmen individually. Owners of smaller properties may club together.
   Credit graded by established standards but so calculated as to make the maintenance of the patrolmen cheaper than paying the premium charged where they are not used.

   b. Privately maintained firefighting tools and equipment. .....
   Credit graded to offer an inducement to owner to possess some private equipment.

   c. Fire warning signs maintained by owner .....
   Credit graded to offer inducement to the maintenance of signs.

   d. Fire lines .....
   Credit graded as inducement to maintain permanent cleared strips.

3. Salvability: .....
   Owner of insured merchantable timber can obtain a graded credit if he can show that the timber would be definitely salvable after loss, and so warrants.

NET RATE: .....

Forest Economics - Economics of Forest Ownership and Exploitation

Phase I - Selective Logging in Douglas Fir

Selective logging, or rather logging according to individual appraisal of each logging unit or type of trees, is based essentially on intensive analysis of costs and returns in converting timber into logs or lumber. The appraisal of a typical Douglas fir area as a whole gives an entirely different set-up than the detailed appraisals of subdivisions consisting of timber of uniform size, quality, and accessibility. The usual appraisal of a tract as a whole consists in determining the grand average value which is made up in part of timber that will be cut at a loss and in part of profitable timber. The selective appraisal determines separate values for each homogeneous unit of such tracts.

Examples of the effect of logging according to economic selection on three acres in the Douglas fir region already studied by Mr. Brandstrom before his connection with the Forest Service are briefed here by way of illustration.

| | Present Basis | | | Selective Basis | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Area Acres | Total Volume | Av. Stump Val. | Total Realization | Area Cut Acres | Total Vol. to be cut | Av. Stump Val. | Total Realization First cut | Area left Uncut | Volume Left | Realization 2nd cut |
| Tract No. 1 | M. ft. | | | | M. ft. | | | | M. ft. | |
| 6,000 | 300,000 | $2.50 | $750,000 | 3,200 | 175,000 | $8.57 | $1,500,000 | 2,800 | 125,000 | Unknown |
| Tract No. 2 | | | | | | | | | | |
| 1,500 | 50,000 | $2.25 | $112,500 | 400 | 24,000 | $9.00 | $ 216,000 | 1,200 | 26,000 | Unknown |
| Tract No. 3 | | | | | | | | | | |
| 2,800 | 120,000 | $3.00 | 360,000 | 1,000 | 80,000 | $8.00 | $ 640,000 | 1,800 | 40,000 | Unknown |

These preliminary studies indicate the possibilities of selective logging from the financial point of view. From the forestry point of view selective logging may have far reaching effects in prolonging cut of the present merchantable stand and in assisting in regeneration and fire protection of the cut-over areas.

It is proposed to make time studies of log skidding and loading with equipment of various types at several operations in the Douglas fir region. Three crews will be in the field this spring, one of which is already at work. The data collected by the Office of Forest Products in the felling and bucking study covering 800 trees are directly usable on this project and will be worked up shortly under the direction of Products.

Case studies of several timber tracts will have to be made to analyze the intrinsic value of each portion of the tract in the light of the logging cost studies. These case studies involve very detailed cruising by quality as well as quantity and cost about $1.00 an acre. The hope was expressed that a major case study may be made on one of the national forest timber sale areas, possible through financial cooperation of the purchaser.

Present plans for the study contemplate carrying the analysis only to the log market, but Mr. Brandstrom felt, and the Committee was unanimous in agreeing, that this is not sufficient for the value grouping required in intensive selective valuation. There is need for time and grade studies of several representative Douglas fir mills in order to determine the intrinsic value in terms of lumber production of logs of different species, sizes and quality. There is a hope that through the West Coast Lumbermen's Association, the industry will give financial cooperation. Without it, Mr. Hodgson stated that

the Office of Products is so limited in funds and personnel that there seems to be no possibility of making such studies during the present calendar year.

As a record of its formal recommendation, the Committee passed a resolution favoring cost and grade studies in Douglas fir sawmills, which is recorded on the Forest Products section of this report.

## Report of the Office of Forest Products, Region 6, For 1930 and Program for 1931

The work of the Office of Products during the calendar year 1930 was largely devoted to utilization and waste investigations, the most important of which were the survey of sawmill waste in the Douglas fir region and the study of felling and bucking in the Douglas fir region. Work on the former study progressed steadily and at the close of the year the status of the project indicated that it would be completed in report form by June, 1931. The felling and bucking study was carried forward until the middle of September, 1930, at which time, due to the serious illness of Spelman, the project leader, it was halted. Since that time practically nothing has been done.

The following tabulation listing the personnel of the office shows the time devoted to each of the projects. It also shows the approximate distribution of salaries and expenses to the various activities durint the calendar year.

This report deals briefly only with major projects which are rather limited in number.

Time devoted to Major Projects in 1930 and Approximate Cost of Each

| Projects or Major Lines of Work | Days | | | | | | Total Man Days | Proportion of Time Percent | Approx Cost of Each |
|---|---|---|---|---|---|---|---|---|---|
| | Gibbons | Hodgson | Johnson | Spelman | Clerk | Asst. Clks. | | | |
| Survey Logging Waste, Douglas Fir Region[1] | — | 4 | -- | -- | 9 | 4 | 17 | .75 | 122.27 |
| Survey Milling Waste, Douglas Fir Region[1] | 13 | 273 | 33 | 15 | 31 | 164 | 529 | 23.39 | 6079.35 |
| Western Yel. Pine Utilization Study, Logging[2] | -- | -- | -- | 9 | -- | -- | 9 | .40 | 70.56 |
| Western Yel. Pine Utilization Study, Milling[3] | 23½ | -- | 23 | 48 | — | 107 | 201½ | 8.91 | 1346.65 |
| Felling & Bucking Study, D.F.Region[4] | 20½ | -- | 116½ | 175 | 2½ | 16 | 330½ | 14.61 | 3379.87 |
| Little-used Species Study[5] | 10 | -- | 30 | — | — | 18 | 58 | 2.57 | 454.26 |
| Minor Forest Products Study[6] | 8 | -- | 29½ | — | — | 7 | 44½ | 1.97 | 374.84 |
| Fire Fighting[7] | -- | 13 | -- | -- | — | — | 13 | .57 | — |
| Trip to Madison, Conference, etc. | 22 | — | -- | -- | -- | — | 22 | .97 | 580.54 |
| Detail to Washington, D. C.[8] | 36 | -- | -- | -- | -- | — | 36 | 1.59 | 453.56 |
| Census, Lbr. Lath, Shingles, etc.[9] | 103½ | 8 | 83 | — | 291½ | 101 | 587 | 25.95 | 4212.28 |
| Guard Training Camp[10] | -- | 13 | -- | — | -- | — | 13 | .57 | 128.16 |
| Miscellaneous | 118½ | 22 | 23 | 4 | 12 | 5 | 184½ | 8.16 | 2148.84 |
| Absent from Duty[11] | 10 | 32 | 27 | 114 | 19 | 15 | 217 | 9.59 | 1088.24 |
| Total | 365 | 365 | 365 | 365 | 365 | 437 | 2262 | 100.00 | 20439.42[12] |

[1] Assigned to Hodgson
[2] Assigned to Spelman & Gibbons
[3] Assigned to Gibbons, Johnson & Spelman
[4] Assigned to Spelman
[5] Assigned to Johnson. [6] Assigned to Johnson
[7] Hodgson. Salary and expenses paid by Fire Control
[8] Gibbons. Expenses paid by Washington office.
[9] Assigned to Johnson
[10] Hodgson. Expenses paid by Operation.
[11] Includes annual and sick leave, leave without pay, and furlough.
[12] Deficit in allotment to be taken care of by Census Bureau reimbursements, etc.

## Progress on Current Projects and Future Plans

### Research - Products

### Utilization and Waste Investigations

Little-used Species (Proj. L-264)

1. "White" Fir and Western Hemlock. -No systematic work was recommended for 1930, and none is recommended for 1931. It may be that some work will be required in connection with reports to be prepared jointly by the Laboratory and the Regional Offices of Forest Products.

2. Pacific Northwest Hardwoods. -A report "Utilization of Bigleaf Maple of thw Pacific Northwest" by Herman M. Johnson was brought to completion in 1929 and submitted to the Forester with the recommendation that it be published as a Department bulletin. The report was returned with the suggestion that it be used as a trade-journal article. Certain changes were made in the report and it was again submitted to the Forester with the recommendation that it be used as a Department bulletin. No further action, as far as this office has been informed, has been taken with respect to this piece of work.

Some miscellaneous data have been collected for the purpose of preparing a report on Oregon white oak. It is the intention of the Office of Products to cover this species by a report similar to the one on Bigleaf maple as soon as sufficient information has accumulated.

At the Regional Investigative Committee meeting some interest was shown toward the collection of data relating to black cottonwood and an effort will be made to collect data on this species in connection with other studies.

It was also suggested at the Investigative Committee meeting that Forest Management be given an opportunity to prepare a silvicultural and management report on such hardwoods as are to be reported on

by the Office of Products. No formal action on this suggestion, however, was taken by the Committee.

Logging, Douglas Fir Region.

1. Felling and Bucking Study (Proj. L-260-(R-6)3. - A scientific study of felling and bucking timber in the Douglas fir region with the ofject of finding ways and means of reducing breakage and other forms of logging waste. While this project was recommended and approved in 1927, it was anticipated that the field work would not start earlier than 1929. The general working plan was approved by the Regional Forester and submitted to the Forester in May, 1929.

As was previously reported, in a quite limited field season in 1929 Mr. Spelman, to whom this study was assigned, visited some 28 camps pursuing a conference method of study as outlined in the working plan. By this method the work included general observations, the securing of information and the determining of opinion from fallers and buckers and particularly from the supervising heads, such as bull buckers and superintendents. In addition to the general work in the logging camps, information was secured as to the essential features of commercial scaling and grading practice in the Douglas fir region, a report of which was completed by Spelman at the close of the field season. As a result of this work he was enabled to work out technicalmethods and standards, more particularly grading rules, for use in this year's program.

At the outset, the plan for this year was to so organize the study that sufficient data would be collected at the close of the season to warrant the preparation of a report dealing with the effect of tree sizes on felling and bucking costs. It was considered that work along this line would be very appropriate at this time and contribute toward

the general study of marginal values in Douglas fir stands. For this reason major attention was to be given to the collection of time-study data in connection with carefully-measured and graded logs. It was considered, also, that the work should be conducted on a unit-area basis insofar as the taking of systematic data was concerned. Unit areas were to be chosen to enable a considerable spread of data as to size and quality of the timber but having more or less uniformity for such factors as ground conditions, skill of the workmen, quality of supervision, method of payment and the like, insofar as this was possible in choosing camps and plot locations.

Although field work commenced in April and continued through September, the amount of data secured was limited to what two men (Johnson and Spelman), one working with the fallers, the other with the buckers, could do. The choice of suitable plots was limited necessarily to going operations which were not numerous, due to the economic depression. Field work was further affected by reduction in working days per week and a prolonged July shut-down by many operators. As a result, only five sample plots, from one to two acres each, were studied in the course of the season, securing data on about 600 trees.

At the present time, the analysis of this year's data has not been completed. Furthermore, these data must be analyzed before it will be possible to confidently determine the extent and character of the data necessary to complete the study.

A report dealing with the effect of tree size on felling and bucking costs is contemplated before next year's field work will be undertaken.

As to future work, it is anticipated that at least one more season of field work, conducted in a similar manner (unit-area method),

will be necessary to round out the present data and supplement the work of this year. Also, the character of the data will probably be modified, more attention being paid to the mechanical phases of the study.

As mentioned above, this project has been at a standstill since the middle of September. It has developed that the field work accomplished contains some information of use to Kirkland and Brandstrom of the Experiment Station for their project "Economic Selection Logging in Douglas Fir". Plans are now being made to have Junior Forester Rapraeger collaborate with Spelman and the Experiment Station in getting the data in shape for immediate use. In the event Spelman is unable to return to work, Rapraeger will carry on the project to completion.

Lumber Manufacture.

1. General Survey of Sawmill Waste in the Douglas Fir Region (Proj. L-260-(R-6)4. - This study consists of determining the quantity and form of wood waste resulting from the manufacture of rough, green lumber produced by the Douglas fir region. Also the present utilization of this material together with its value in by-product form. Hodgson, as project leader, devoted practically his entire time to this study and it is now being worked into report form. It is the plan to cover the project by two reports, one for the files and the second for publication as a trade-journal article.

This project was reported on rather fully at the Regional Investigative Committee meeting. It was brought out that the sawmills of western Oregon and Washington during the manufacture of the 1929 cut of rough, green lumber produced 617,247,992 cu.ft. (solid measure) of so-called sawmill "waste". Of this amount, 44.0 per cent was re-

claimed by the sawmills and sold as by-products, such as lath, handle squares, shingle bands, pulp wood, pulp chips, fuel wood, hogged fuel, sawdust, etc., with a total return at the point of production of $7,144,075. It was shown that 28.8 per cent of the waste was being used by the sawmills as fuel in the production of domestic power, a very legitimate use when it is known that in heat value the waste used for this purpose is equivalent to nearly five million barrels of crude oil. It was also shown that 27.2 per cent of the waste, or 167,815 280 cubic feet (solid measure) was still being sent to the refuse burners and destroyed as true waste. Hodgson stated that it was one of the ultimate objects of the study to find ways and means for reducing this 27.2 per cent of true waste at a profit to the industry.

2. Reduction of Sawmill Waste Through the Study of Factors Which Cause It. (Proj. L-260-(R-6)6. - A new study which will be centered on the methods, mechanics and labor problems which tend to cause sawmill waste. This is to be the second phase in the general study of sawmill waste in the Douglas fir region. It was discussed in the working plan covering "The Survey of Sawmill Waste in the Douglas Fir Region" and was to be considered as the follow-up study after the survey was completed.

The man assigned to this project will be able to use the results of the survey by Hodgson as background but it will be necessary to prepare a complete and detailed working plan. To do this will require more or less exploratory work. It is probable that the working plan can not be completed before the end of 1931.

3. Time and Mill-Scale Studies in the Douglas Fir Region. - A strong sentiment was evidenced by the Committee favoring "Cost and grade studies in Douglas fir sawmills", for including in the 1931 program of

the Office of Products. Forest Management of the Regional Office and several project leaders handling Forest Experiment Station work mentioned that such studies were needed badly and were quite necessary. The offices of Plant Pathology and Entomology also expressed interest in such a project.

The following resolution was adopted by the Committee:

> Resolution. - The need for cost and grade studies in Douglas fir sawmills being recognized, it is moved that such studies be considered of major importance in the Office of Product's plan of work, that additional funds to take care of such studies be requested in the allotment of funds and that other interested agencies be asked to contribute to the project.

Chairman C. J. Buck stated that he would like to have the Office of Products and the Forest Experiment Station get together and work out a plan that would insure getting the necessary information to be provided by studies in Douglas fir sawmills.

4. Time and Mill-scale Studies in the Pine Region. There is some material contained in the field data of the Shevlin-Hixon and Mt. Emily Mill-Scale studies which is yet to be put into report form. One or two additional mill-scale studies in yellow pine sawmills should be conducted in order to round out the information presented by this project.

5. Deterioration of Fire Killed Douglas Fir Timber - The sapwood of fire killed Douglas fir is rather rapidly destroyed by various fungi, but the heartwood remains sound for many years if not attacked by certain wood-borers. Because of the importance of this problem in the ultimate salvage of fire killed Douglas fir, the Committee recommended that a cooperative study of the problem be undertaken by the offices of Forest Products, Forest Entomology and Forest Pathology as soon as such a study can be started without detriment to going projects.

Pulp and Paper Manufacture.

1. Utilization of Sawmill Waste and Forest Wood (Proj. L-260-R-6)7.

The pulp and paper industry of western Oregon and Washington, in recent years, has reached importance as a factor in the use of wood. Large quantities of this wood are used by the industry in the form of sawmill waste as well as forest wood. It is believed that from the Forest Service standpoint more should be known regarding the quantities, character and relative value of the two classes of material. In addition to these matters the study will enter into the methods used in preparing sawmill waste and forest wood for chipping.

## Wood Preservation

Service Tests (Proj. L-214). - Except for some service tests on a few national forests, no intensive work in this general field will be done by the local office.

## Research - Economics

### Production of Forest Products

Census of Lumber, Lath, Shingles, Veneer, Cooperage and Logs. - Cooperation was extended the Bureau of the Census in taking the lumber, lath, shingle, veneer, cooperage and log census of Oregon and Washington for 1929. Cooperation will also be extended to the Bureau in taking the lumber, lath and shingle census for 1930. The 1929 census figures just released by the Bureau of the Census indicate that the 1929 lumber cut for Oregon and Washington exceeded the 1928 cut by 370 million feet. These figures show that a total of 12,047 million feet of lumber was produced in 1929 by the two states, the maximum for any year to date.

Study of the Industries Producing Minor Timber Products in Oregon and Washington (Proj. L-260-(R-6)5. - The major objects of this study, which is new in the Forest Products program, are: To collect information that will supplement the Bureau of the Census and other statis-

tical data with particular regard to the needs of the requirements phase of the forest survey; to determine the extent to which minor products serve or can be made to serve as a means of utilizing so-called wood waste; to determine the extent to which second-growth timber is used for minor timber products, etc.

Depletion Phase of the Forest Survey - The Office of Products will be called upon to contribute data, statistical in character, for the use of the Forest Survey of the Douglas fir region.

Program for 1931 - Including New Projects

The major projects included in the 1931 plan of work are referred to in the preceding discussions and also on the project sheets. A further discussion of these projects does not seem to be necessary. They are, therefore, simply listed as follows:

1. Felling and Bucking Study in the Douglas Fir Region.

2. Study of Industries Producing Minor Timber Products.

3. General Survey of Sawmill Waste in the Douglas Fir Region to be Completed by June 1931.

4. Reduction of Sawmill Waste Through the Study of Factors which Cause It.

5. Utilization of Sawmill Waste and Forest Wood for Pulp.

6. Cost and Grade Studies in Douglas Fir Sawmills.

7. Census of Lumber, Lath and Shingles, 1930.

Financial Statement Fiscal Year 1932

The allotment for the fiscal year 1931 for Forest Products was $19,020.

Owing to the fact that Hodgson is to be transferred to the administrative branch and his successor has not been selected, and to the uncertainty of Spelman's return to work on account of illness, and other

uncertainties, it is difficult to prepare a financial statement for the fiscal year 1932 at this time.

The following figures are therefore tentative and are presented on the basis of the present personnel, with the assumption that Hodgson will be transferred on July 1, 1931 and that Spelman will return to work before the beginning of the Fiscal Year 1932.

| | |
|---|---|
| Salaries - Permanent and Temporary | $19,500.00 |
| Travel Expenses, Temporary Labor, etc. | 5,100.00 |
| Total | $24,600.00 |

Of this amount it is assumed that the Bureau of the Census will reimburse the Forest Service for work to be done on the lumber census in the amount of $600.00.

## Publications and Manuscripts

Publications: None

Articles, Reports, Addresses

"Timber Waste Large in the Northwestern Douglas Fir Forests" by Allen H. Hodgson, published in the Agriculture Yearbook for 1930.

"Logging Waste: A Challenge to the Pulp Industry of the Douglas Fir Region" by Allen H. Hodgson. An address given before the Pacific Coast Section of the Technical Association of the Paper Industry at Longview, Washington. Published by The Paper Industry with 100 reprints supplied.

"The Effect of Tree Sizes on Western Yellow Pine Lumber Values and Production Costs", by Gibbons, Johnson and Spelman, published by The Timberman with 600 reprints supplied.

"Felling and Bucking Study in the Douglas Fir Region", an address by W. H. Gibbons before the Pacific Logging Congress, Vancouver, B. C. Published by the West Coast Lumberman.

"Logging Waste in the Douglas Fir Region" by Allen H. Hodgson. An address before the Linnton Community Club, Linnton, Oregon.

"Air Seasoning of Douglas Fir Common Lumber" by H. M. Johnson. An address before the School of Forestry, Oregon State College, Corvallis, Oregon.

## Program for Research in Range Management

The Committee believes that the time has arrived when grazing research should be established in Region 6. It believes that the present program is unbalanced in that every other major activity except grazing is represented. On at least one-half the area of the Region any form of management must take into account the effects and influence of grazing use. This may or may not be done wisely since grazing research has not been applied to these problems here.

As with fire and silvical studies the results secured from grazing research in other Regions are not generally applicable here because the conditions in this region as they relate to species, soil, climate, etc. differ so widely from those in the Regions where grazing research has been conducted. Some years ago grazing studies work on a limited scale was initiated in Region 6, under the supervision of the Office of Range Management. Later, due to the instability of allotments and the uncertainties surrounding personnel assignment the Region agreed to discontinue the work for the time being and allow concentration of studies funds on grazing research in other Regions.

The Committee is recommending, therefore, that grazing research be established in the Region, under the supervision of the Pacific Northwest Forest Experiment Station; that the personnel of the Station be expanded immediately to take care of such work and that the necessary funds be allotted to finance a grazing research program.

One project is recommended for inclusion in the 1931 program - Relation of Grazing to Plant Growth and Fire Hazard in the Fort Rock Region, and it is hoped that funds and personnel can be made available for initiating some work on this project this year.

Other projects recommended for study when funds are available include:

Re-Seeding Burns to Forage Plants

This study is desired primarily to determine the feasibility of re-seeding burned over areas in both Douglas fir and Western yellow pine to forage plants;- the species best suited to the purpose and the effect of artificial range revegetation on fire hazard and tree seedlings.

Grazing Douglas Fir Cut-Over Land

The purpose of this study is two-fold; one, to determine the extent to which Douglas fir cut-over lands can be grazed by sheep without injury to tree reproduction, and; two, to determine the economic possibility of utilizing Douglas fir cut-over lands for sheep grazing purposes. Some years ago some work of this nature was initiated in the Region but for various reasons was not carried to conclusion. A study of this kind in order to be successful necessitates close cooperation on the part of stockmen who are equipped with the finances, plant and experience to operate over a reasonably long period of years. In other words, it is necessary to select both a site suitable for the study and stockmen who can be depended upon to go through with it.

In the Eastern portion of the Region full grazing use of Western yellow pine cut-over lands, both National forest and private, is secured. On private lands this use reduces the taxation and fire protection costs and on both private and National forest cut-over land the value of grazing in reducing the fire hazard is fully recognized and appreciated. Demand for range in the Eastern portion of the Region is far in excess of the supply. The acreage of Douglas-fir cut-over land is increasing annually and coincident therewith is an increase in the tax burden on

private lands and an increase in fire hazard on both private and National forest land. If sheep grazing on Douglas fir cut-over land can be utilized to reduce taxes and fire hazard without undue injury to tree reproduction and if it is economically feasible to utilize these lands with sheep from the Eastern portion of the Region it is high time that something be done about it. Potential possibilities in the way of releasing pressure on the ranges in the Eastern portion of the Region to the extent of one-fourth million head of sheep and taking care of that number on the Douglas fir lands West of the Cascade mountains, as well as the consequent reduction in the tax burden and fire hazard, certainly are of sufficient importance to justify a permanent place in the research program for the Region.

Effect of Fire on Soil Productivity.

The purpose of this study is to determine the effect of repeated burning on soil productivity as related to forage and tree growth. In the Douglas fir region generally and on the Umpqua Forest particularly there exists a rather marked tendency on the part of the local residents to keep the land free of brush and timber by repeated burning. Their objective appears to be an increased acreage of grassland suitable for range purposes. On the Umpqua the problem involves incendiarism and to some extent grazing permittees are suspected. Timber sale operations on both private and Government stumpage will soon be under way on that Forest and the resulting increased acreage of slash and the local tendency to perpetuate such areas in grass through repeated burning is expected to add to the seriousness of the problem.

Clipping Studies

The purpose of these studies would be to determine by artificial means the extent to which the principal forage species in Region 6 may

be utilized without impairing their productivity. Similar studies have been conducted in other Regions, notably the Black Grama projects in Region 3, but the results, as heretofore indicated, are not applicable here. Information is needed on at least the following species - Festuca viridula, Festuca idahoensis, Agropyron spicatum, Poa sp., Aira caespitosa and Kunzia tridentata.

Intensive Erosion-Stream Flow Study

The services of a grazing expert will be absolutely necessary in connection with the contemplated erosion-streamflowflow studies in eastern Washington and Oregon. The purpose of these studies is to discover how the forest and range lands of that region may be managed so as to prevent erosion and regulate streamflow. These problems are of tremendous importance to many large communities, to owners of irrigated lands of high value, to irrigation and water power systems, and stockmen.

Big Game

Studies are needed to determine the food requirements of elk herds on the Rainier and Whitman Forests and to develop game management plans designed to perpetuate these herds and at the same time keep the numbers within the limits of feed production possibilities of the areas involved.

# Report for 1930 and Program for 1931 of the Office of Forest Pathology, B.P.I.

By J. L. Mielke, Assistant Pathologist

## Investigations

The projects of this office in 1930 are here briefly discussed. No projects were added during 1930 nor any new ones scheduled for the coming year.

### General Forest Pathology

This project is concerned with the general investigations, evaluation, and reduction of pathological loss factors in Pacific Northwest forests. Its most important function is disease prevention. For this purpose it is essential to keep informed as closely as possible not only of general disease conditions within the region, but of foreign diseases which may be serious if introduced. Disease reconnaissance was carried out as usual in connection with travel and work on the other projects. In this way a considerable portion of the region was covered. Fifty-six reports and inquiries concerning diseases, generally accompanied by specimens, were answered during the year. No serious disease outbreaks or foreign diseases were noted within this region. A physiological disturbance primarily caused by drought was reported and observed on reproduction of Douglas fir, incense cedar, and to some extent, on western yellow pine in the eastern Cascade foothills of Oregon. The injury was concentrated principally in small local areas representing marginal conditions on the dryer sites for these species. Instances of rather severe damage caused by this same form of injury to extensions of the western yellow pine forest in north-central Washington and central Oregon were also reported.

Decay of Slash in the Douglas Fir Region

Field work on this project during the past year was limited to re-examination of some typical areas, the study of additional slashings in the spruce belt, and a preliminary comparison of moisture conditions on burned and unburned slashings. Unfavorable weather interfered with the latter to a large extent. Results are not yet available, but observations to date indicate that moisture content of logging debris averages considerably higher on unburned than on burned slashings, particularly in the forest types west of the Coast Range summit. Future field work will be principally concerned with this study of moisture content relationships.

Decay in Western Yellow Pine Slash

No work was done on this project in 1930 and none is contemplated in 1931. In the future, however, further examinations of decay conditions on Experiment Station permanent slash disposal study plots will be made.

Deterioration of Wind-thrown Timber.

Data taken during the summer of 1929 were computed last year. Heartwood of Douglas fir and western red cedar remained sound, although the sapwood of these species was decayed. Western hemlock was a complete loss. Decay in spruce varied from about 75 per cent of the volume in the 30-inch D.B.H. class to about 35 per cent in the 86-inch D.B.H. class.

White Pine Blister Rust

The year 1930 was found to be relatively unfavorable for long distance spread from pines to Ribes, and the rust was not found nearly so far south as in 1929. Very little extension in the range of rust on pines in Idaho was noted. With the finding of infected pines near

the Independence Prairie Ranger Station on the Santiam National Forest, however, the known range of the rust on pines in Oregon was extended about fifty miles farther south. The infection at this place dates back, apparently, to 1923. This is an important find, since it establishes the rust for the first time on western white pine within the range of sugar pine. The rust has not been found on sugar pine to date. Continued susceptibility studies in British Columbia have substantiated previous evidence that sugar pine is slightly more susceptible than western white pine, and that the two chief Ribes associates of sugar pine in its main commercial range are also highly susceptible to the rust. Contrary to previous preliminary indications, studies this year showed that the two timber-type species of Ribes common in the Inland Empire white pine region have a considerably greater capacity to spread infection to pines than had been anticipated. This knowledge has called for a speeding up and enlargement of the control program.

Nursery Disease Control

Experiments at Wind River nursery were continued by Messrs. Kummel and Will in 1930. Good control of damping-off was again secured by the use at various strength of sulfuric acid and of aluminum sulfate. Zinc chloride in solutions weak enough not to cause chemical injury to the seedlings was considerably less efficient in controlling damping-off, and was also less satisfactory in controlling weed growth.

## Publications and Manuscripts

Publications: None

Manuscripts:

Lachmund, H. G.: Comparative resistance of the current season's needles of western white pine to investions of *Cronartium ribicola*.

---- Method of determining the age of blister rust infection on western white pine.

---- Field studies of the incubation period of *Cronartium ribicola* Fisch. on *Pinus monticola* D. Don.

---- Field studies of the age of susceptibility of Ribes spp. leaves to *Cronartium ribicola* Fisch.

---- Growth measurements of blister rust cankers on western white pines.

---- Studies of the susceptibility to *Cronartium ribicola* Fisch. of *Pinus albicaulis* Engel.

---- Field studies of the incubation period of *Cronartium ribicola* Fisch. on some western Ribes.

---- Decay of slash in the coastal fog belt of northwestern Oregon and western Washington.

---- & Mielke, J. L.: The extent and effects of squirrel gnawing of blister rust cankers on western white pine

Lachmund, H. G. & Childs, T. W.: Decay of slash in the Douglas fir type proper of northwestern Oregon and western Washington.

# Report for 1930 and Program for 1931

# of the Forest Insect Field Station, B.E.

By F. P. Keen, Bureau of Entomology

## Investigations

The research carried on by the Branch of Forest Insect Investigations covers the three major fields (1) insects affecting commercial and recreational forests, (2) insects affecting shade and ornamental trees, and (3) insects destructive to forest products. However, the research work at the Portland office is confined to the problems of insects in commercial and recreational forests; since research in the other two fields is carried on by specialists of the Washington office.

The more important insect problems of the commercial and recreational forests of this region have to do with means of protecting mature or growing trees from insect attack; methods of minimizing insect damage during the transition from mature to second growth stands and problems of silviculture, in connection with the growing of a second forest crop, so as to avoid insect outbreaks and various types of damage.

The insect problems falling into these three classes are multitudinous and extremely varied. For the present, however, on account of limited funds and personnel, the study of only a few of the more important can be attempted. Seven projects have been selected for the coming year. These have been selected with a view to their economic importance, the interest of cooperators and the possibility of securing tangible results in the near future.

The effectiveness of the present methods of barkbeetle control, especially those used in the control of the western pine beetle, have been the subject of investigations since the starting of the Southern Oregon-Northern California Pine Beetle Control Project in 1921. It is hoped that the final report on this project can be prepared at the end of the coming year. Surveys of check plots both on the treated units and on adjacent untreated units have been made from year to year as a basis for comparing the results of the work with areas where no work has been done. In general it may be said that the control work has had very tangible results for a season or two, but lasting results have not been obtained, especially on areas of poor growth and during years of low tree vitality, unless the work is continued.

The effect of dry weather cycles in lowering tree vitality and increasing the tree's susceptibility to barkbeetle attack seems so important, that a study is under way to determine how close a correlation exists between climate and barkbeetle epidemics. The annual surveys which are carried on in the southern Oregon region give the basic data as to barkbeetle epidemic trends which can later be correlated with the various weather factors. We are very much in hopes that this study can be extended to other portions of the western yellow pine type within the region, so as to give a broader basis upon which to draw conclusions. This can only be done through cooperation with the Forest Service and Indian Service since data must be obtained on specific plots over a much wider area than can be covered by the survey crew of the Bureau of Entomology. This data could be obtained in connection with a general regional insect detection survey which is a recognized function of the Forest Service and is carried as a regular activity in most of the Forest Service Regions.

During the past year a study was started in the western yellow pine logging operations of the Weyerhaeuser Timber Co. west of Klamath Falls to determine the effect of a large logging operation upon the abundance of barkbeetles within and adjacent to the area. More specifically it was desired to know to what extent insects breed in slash and cull material and then attach the virgin or reserve stands near the logging operation. Records late in the summer showed that great quantities of beetles were absorbed by the logs and later destroyed at the mill. This study will be continued for another season to obtain one full year or records.

Mr. Beal has made considerable progress with his study of western yellow pine slash disposal methods and barkbeetle abundance. He has found that the lopping and leaving of slash exposed to the sun, such as is practiced on the Weyerhaeuser Timber Company's operation near Klamath Falls, results in the breeding of comparatively few destructive insects. Piled slash or slash that is shaded in any way produces about six times as many beetles as exposed slash. For the coming summer Beal will extend this study to other sale areas and other methods of slash disposal. So far the results from the entomological standpoint support the conclusions of the Experiment Station as to the most desirable slash disposal practice.

In connection with this slash study, Mr. Beal is carrying on rather detailed experiments as to the moisture and temperature requirements of the barkbeetles which will help to interpret the behavior of these beetles under varying conditions of host material and in relation to seasonal climatic changes.

A survey of the Oregon coast region during last summer failed to uncover any defoliators of economic importance. However, late in the season our attention was called by cruisers of the Weyerhaeuser Timber Co. to an outbreak of some defoliator on the Nasell River in Pacific County, Washington. Upon investigation this turned out to be the very destructive hemlock looper. Already about 500 acres of hemlock apparently have been killed by it and egg laying has extended to about 5000 acres. During the coming year biological studies will be conducted on this pest and some experimental control work attempted.

Sitka spruce is slowing dying over great areas along the coast of Oregon and Washington. The cause of death is rather obscure and there seems to be a number of insects and physiological factors involved. The amount of damage certainly warrants some investigative work, especially since it is a problem which has received very little attention in the past. This study will involve a determination of the cause of the dying spruce, the insects associated with the injury and the silvicultural and physiological factors which may play a part. It is a problem in which the cooperation of the forest pathologists would be most desirable. It is hoped that a start on this problem can be made during the coming year.

## Discussion

In the discussion which followed the presentation of the Forest Insect Field Station's program, the Committee expressed itself as endorsing the program and in particular the urgency of carrying on some experimental control of the hemlock looper. This was particularly urgent on account of the present small area affected and the rapidity of spread which may occur during the next few years.

Mr. Munger stated the need for an investigation of the deterioration of fire killed Douglas fir, particularly the part which insects play in destroying the heartwood. He proposed that a joint study be made of this problem by entomology, pathology and the forest products office.

Mr. Hanzlik also called attention to the fact that the minor studies committee had approved the cooperation of the administrative force of the forests in the pine region in the enlarging of a major project of the office of forest entomology. This project was concerned with the detection of barkbeetle outbreaks and the determination of the annual forest drain from insect activity. The work for the coming year would consist of assistance to the entomologists in the cruising of permanent sample plots in four of the east side forests. Only such work would be undertaken as could be directly supervised by the etomologists. The study would also have the advantage of familiarizing forest officers with the important insects of their districts and in helping them to recognize the early states of barkbeetle outbreaks. This project met with the approval of the committee as a whole.

## Resolutions

The following resolutions relating to forest entomology projects were adopted:

### Hemlock Looper

> Due to the serious nature of outbreaks of the hemlock looper and the tremendous losses of timber which may result therefrom, this committee strongly recommends that action be taken by the Forest Insect Field Station to determine what can be done to stop the present outbreak on the Naselle River in Washington while only a small acreage is affected. The committee believes that this is one of the most important projects which can be undertaken by forest entomology in this region at the present time.

## Deterioration of Fire Killed Douglas Fir.

The sapwood of fire killed Douglas fir is rather rapidly destroyed by various fungi, but the heartwood remains sound for many years if not attacked by certain wood-borers. Because of the importance of this problem in the ultimate salvage of fire killed Douglas fir, this committee recommends that c cooperative study of the problem be undertaken by the offices of forest entomology, forest pathology and forest products as soon as such a study can be started without detriment to going projects.

## Priority of Projects

The following priority is given to the projects now under way and those which have been proposed:

| Priority of Going Project | Status |
|---|---|
| 1. Regional Insect Survey and Relation to Climatic and Other Factors. | To be expanded |
| 2. Barkbeetle Control | To be completed in 1932 |
| 3. Coniferous Defoliators | Work to be increased |
| 4. The effect of a large logging operation on beetle infestations | To be completed in 1932 |
| 5. Insects and yellow pine slash disposal | To be completed in 1932 |
| 6. Relation of temperature and moisture to barkbeetles | To be completed in 1932 |
| 7. Insect enemies of Sitka spruce | Indefinite |

Proposed New Projects

| | |
|---|---|
| 1. Insects in relation to drain phase of forest survey | To start in 1931 |
| 2. Control of hemlock looper | Dependent upon funds |
| 3. Deterioration of fire-killed Douglas fir | To be undertaken when funds are available. |

## Forest Entomology Allotment for 1931

| | |
|---|---|
| Salaries - | |
| Regular employees - (3) | $8,600.00 |
| Field Assistants | 940.00 |
| Field expenses - regular men | 1,000.00 |
| temporary men | 500.00 |
| Station expenses | |
| Rent | 720.00 |
| Equipment and supplies | 200.00 |
| Miscellaneous | 40.00 |
| Total Allotment | $12,000.00 |

The present allotment is barely sufficient to provide for work on the seven major projects which have been outline and the cooperative work on surveys and control projects which takes about one-third of the total time. Any expansion of the research work on problems which have been suggested will depend upon the securing of additional funds.

Reports Prepared

F. P. Keen - "Forest Entomology in Western United States" (Paper presented at A.A.A.S. meeting June 1930)

"An Outbreak of the Hemlock Looper (Ellopia fervidaria) in Pacific County, Washington, 1930". November 15, 1930.

"The Mountain Pine Beetle Situation in Rainier National Park, Fall 1930". November 15, 1930.

"Mountain Pine Beetle Situation in Crater Lake National Park, Fall 1930". December 1, 1930.

"Estimating Pine Beetle Losses During Period of Attack, February 1931.

J. A. Beal - "Insect Increase in Logging Operations in Western Yellow Pine". January 15, 1930.

"The Effect of a Large Logging Operation on Beetle Population". December 1930.

## PRIORITY RATINGS OF PROJECTS ASSIGNED TO FOREST SERVICE

(Requested in Mr. Clapp's letter of December 15, 1930)

Projects are listed in order of importance, most important first, for each major class of studies.

| | Estimated Cost for FY 1931 from Research funds only | Supplementary index of priority* |
|---|---|---|
| **Forestation studies** | $1,000 | |
| Douglas fir nursery practice | | A-2 |
| Field planting and seeding of Douglas fir | | A-3 |
| Planting and seeding of secondary species | | A-3 |
| Nursery practice for secondary species | | A-3 |
| Douglas fir heredity study | | B-2 |
| Regional races of western yellow pine | | A-3 |
| Tests of exotics | | A-3 |
| Storage of noble fir seed | | A-3 |
| **Forest Influences** | | |
| Erosion and streamflow control (Wenatchee Forest) | $ 500 | C-1 |
| **Management studies** | $14,000 | |
| Natural reproduction of Douglas fir | | A-1 |
| Douglas fir slash disposal | | B-1 |
| Methods of cutting western yellow pine | | A-2 |
| Thinnings in Douglas fir | | B-2 |
| Thinning sapling western yellow pine | | C-3 |
| M-1-WO Private timber growing | | B-3 |
| **Mensurational studies** | $ 6,000 | |
| Growth and yield of western yellow pine | | B-1 |
| Douglas fir growth study (permanent plots) | | A-2 |
| Collection of volume data | | B-3 |
| 1-WO regional growth and yield | | B-3 |
| 2-WO Converting factors | | B-3 |
| 3-WO manual of research methods | | B-3 |
| **Fire protection** | $22,000 | |
| Douglas fir slash disposal (see Management Studies, above) | | |
| Time factors in fire control | | A-1 |
| Fire damage | | C-1 |
| Fire behavior | | B-1 |
| Equipment for fire suppression | | A-2 |
| Static and lightning storms | | B-1 |
| Reporting lightning storms | | A-3 |
| **Botanical studies** | $ 200 | |
| Phenological observation in the Douglas fir region | | A-3 |

(continued on next page)

| | Estimated Cost for FY 1931 from Research funds only | Supplementary index of priority* |
|---|---|---|
| **Economic Studies** | $98,500 | |
| Forest survey of the Douglas fir region | | A-1 |
| Forest insurance in the Douglas fir region | | A-2 |
| Selective logging in the Douglas fir region | | A-1 |
| **Products studies** | $20,000 | |
| Annual lumber and forest products census | | A-1 |
| Lumber, lath, shingle, log and stumpage prices | | A-2 |
| Survey of sawmill waste in the Doug. fir region | | A-1 |
| Minor timber products | | C-1 |
| Time and mill scale studies in the Douglas fir region | | C-1 |
| Felling and bucking in the Douglas fir region | | B-1 |
| Reduction of sawmill waste in Doug.fir region | | B-1 |
| Lumber manufacture in the western yellow pine region | | B-2 |
| Utilization of sawmill waste and forest wood for pulp and paper. | | C-2 |
| Air-seasoning of wood | | B-3 |
| Utilization of white fir | | B-3 |
| Utilization of Pacific Northwest hardwoods | | B-3 |
| Utilization of western hemlock | | B-3 |
| **Range management** | $ | |
| Relation of grazing to plant growth and fire hazard in the Fort Rock area | | C-1 |

*Explanation of symbols for supplementary indices of priority:

A. Current work which can not possible be discontinued for a year or more
   1. First rank of urgency
   2. Second rank of urgency
   3. Third rank of urgency

B. Current work which could be dropped for a year if necessary
   1. First rank of urgency
   2. Second rank of urgency
   3. Third rank of urgency

C. New projects
   1. First rank of urgency
   2. Second rank of urgency
   3. Third rank of urgency

## NEW PROJECTS SUGGESTED FOR INITIATION IN FY 1933

A discussion of the more important new activities and projects which should be undertaken in this region and for which appropriations should be sought for the Fiscal Year 1933 follows, as requested in Mr. Clapp's letter of December 15, 1930.

The new studies are:

1. Establishment of range research in the Northwest.
2. Control of erosion and regulation of streamflow in central Washington.
3. Control of erosion in eastern Oregon.
4. Management of "second growth" stands of Douglas fir.
5. Growth and yield studies in the spruce-hemlock type.
6. Forest survey of eastern Oregon and Washington.
7. Forest economic study of the new public domain.
8. Forest insurance in the western yellow pine region.

### 1. Establishment of Range Research in the Pacific Northwest

(a) To establish research in range management in Washington and Oregon under the jurisdiction of the Pacific Northwest Forest Experiment Station.

(b) The grazing industry in this region represents an investment of approximately two hundred fifty million dollars furnishing employment to over fifty thousand people and indirectly involving a great many others. On the national forests of Washington and Oregon alone over one million head of sheep and cattle are grazed annually returning $210,000 in grazing fees. In many instances, grazing is the only industry possible on large acreages of public and private land. The influence of grazing must be considered in developing management plans for

at least half of the national forests of these two states. Proper weight can not be given this influence until the exact effect of grazing can be determined. The results of grazing research in other regions are not generally applicable here because of appreciable differences in climate, soil, vegetation and other factors. Funds are asked to provide for expansion of the activities of the Pacific Northwest Forest Experiment Station so that research in range management can be started immediately. The services of at least one full time man of the associate grade would be required; with temporary assistants, field expenses, and equipment, an annual expenditure of about $10,000 is involved.

(c) Specific projects on which information is needed urgently are the feasibility of reseeding of burns to forage plants, the species best suited to the purpose and the effect of artificial range revegetation on fire hazard and tree growth; the possibility of utilizing cut-over lands in the Douglas fir type for sheep grazing to release the pressure on the ranges in other types; to determine the effect of grass and slash fires on soil productivity and forage values; to determine the extent to which the principal forage species in these states may be utilized without impairment of their productivity; to determine the food requirements of such big game as elk and the best management of this game; to determine the effect of grazing on watersheds above irrigation and water power systems and to develop satisfactory range management plans for such critical areas; how to secure maximum reduction in fire hazard without damage to forage or tree reproduction.

(d) This work affects a large number of stockmen, owners of irrigation and water power projects, owners or irrigated lands of high value, owners of cut-over lands in the Douglas fir region. Cooperation may be expected from these people.

(e) No grazing studies have been made in these two states for several years; a few studies of restricted scope were made a few years ago.

2. Control of Erosion and Regulation of Streamflow in Grassland and Open Timber Types of Central Washington

(a) The purpose of this project is to develop a plan of management for lands on watersheds above irrigation and water power systems which will insure a well regulated run-off, reduce sedimentation of reservoirs and prevent erosion.

(b) The fine, loose soils of central Washington are easily eroded; sheet and gully erosion on these lands is conspicuous. Irrigation and water power reservoirs are being filled with sediment resulting from excessive erosion. Irrigated land values are high. The causes of and best means of preventing this erosion must be found as quickly as possible as the problem yearly becomes more serious and adequate future control more questionable. The water users have objected strenuously to grazing on these lands, supposing that the amount of the run-off was affected unfavorably thereby. The region is one of scanty precipitation and all the water possible must be conserved for irrigation purposes. Grazing may be found to assist in water conservation by reducing the use of water by vegetation; on the other hand, it may favor erosion or rapid run-off. A solution to these problems is urgently needed. Estimated cost of discovering the basic facts necessary to devise remedial methods is $25,000 for four years.

(c) Study of water requirements of various classes of vegetation, of the water holding capacity of various types of soil cover and soil, of the influence of various methods of range management and timber man-

agement to run-off and regulation of streamflow. Development of other means of water control.

(d) This project affects several large communities a large number of owners of irrigated lands having high value, and the owners of water power and irrigation systems. Stockmen using the watershed ranges also are affected. Active cooperation may be expected from these people. Problems of national forest administration are dependent upon the results of this study.

(e) No systematic research is being done on this problem.

3. Control of Erosion in the Blue Mountains of Eastern Oregon

(a) The object of this study is to discover some means of minimizing erosion of forest and range land in the Blue Mountain region of eastern Oregon and Washington.

(b) Severe loss of soil by sheet and gully erosion over several million acres, mostly public land, is resulting in range depletion and considerable damage to farm and irrigation projects. Methods for stopping erosion and restoring vegetative cover to these lands must be devised. Estimated cost $10,000 for three years.

(c) The exact underlying principles governing this erosion are unknown; it is sometimes obviously related to unwise range management, or to excessive timber removal, or to fire, or to some combination of these. It will be necessary to determine the relation of various types and densities of cover to water run-off before any practical method of erosion control can be developed for these lands.

(d) This project vitally affects all water users of the region concerned, the stockmen, the communities, the timberland owners, and the public. This project would undoubtedly have the support if not the active cooperation, of local interests.

(e) No work is being done or has been done on this problem in this region so far as known.

4. The Economic Aspects and Desirable Silviculture for Profitable Management of "Second-Growth" Stands of Douglas Fir.

(a) The purpose of this study is to develop a system of management for so-called second growth stands of Douglas fir, adjusting the balance between economic considerations and the silvicultural treatment of these stands so that the owner will obtain a profit, the present enormous wastage will be reduced and the forest will be perpetuated.

(b) There are approximately 5,000,000 acres of Douglas fir forests from 20 to 120 years old in the Douglas fir region of Washington and Oregon. This amounts to about one-fifth of the total forest acreage of the region. About half of this acreage is privately owned. As the present old-growth forests are logged a large part of the timber supply of this region must come from these "second-growth" stands of timber.

Some of these immature forests already are being logged. Stands as young as 40 years of age are cut by operators of portable sawmills, of which there are many in the region operating exclusively on immature timber. The present methods of exploitation of these young forests are exceedingly crude and inevitably result in astonishingly large wastage of timber which is just entering the most rapid growth period of its entire life cycle. The large amount of low-grade material thrown on the lumber market by these small mills presents a very serious problem to the mills cutting old growth. Unscientific methods of slash disposal ordinarily result in the death of the large number of trees left after logging thus creating a fire hazard which for many years menaces adjoining properties and endangers any new growth which may originate. As a result, the future timber resource of the region, as represented by these immature forests, is being depleted.

No remedy for this situation can be proposed until thorough study of the problem is made. Operators of small mills and owners of second-growth timber are amenable to suggestions for improving the present unsatisfactory conditions but must have definite information upon which to act.

Six thousand dollars per year for three years would be needed to enable one man of Associate Silviculturist grade, with necessary temporary assistants, to devote his full time in obtaining the desired information.

(c) The information required includes such items as the follwing Character and extent of immature stands and their ownership; operating costs of logging such stands by various methods together with the value of the product; how net profit would be affected by taking out more or less material at this time; the amount and kind of material now wasted and how this would be influenced by a lighter or heavier cutting; how the rate of growth is affected by various degrees of thinnings; the amount of light required to insure natural restocking of the cut-over area with forest growth; the severity of thinning which can be done consistent with reasonable security from windfall; the many ramifications of the financial aspects of the situation, including taxation, protection, other holding costs and probable future returns.

(d) A small amount of cooperation by the local forest schools probably could be obtained. As this problem is partly a farm woodlot problem and ties in with farm management the Agricultural Experiment Station might be interested.

(e) A large amount of information relating to this problem has been collected by various agencies and could be used to good advantage.

From the Forest Survey can be obtained facts on acreage, location and ownership of immature forests. The study of economic selective logging, the recent woods-waste survey of the Office of Forest Products and the proposed mill scale studies, although primarily for old-growth timber would constitute valuable data. Some work has been done by this Station in ascertaining the principles involved in the silviculture of such stands. The recent study of the yeild of second-growth Douglas fir forests and the few existing sample plots to study the effect of thinnings in second-growth Douglas fir could be a start in the growth phase of this study.

5.Growth and Yield Studies in the Spruce-Hemlock Type.

(a) To determine the growth and yields of immature stands of sitka spruce and western hemlock in the coast region of Oregon and Washington.

(b) The pulp industry of the Pacific Northwest is rapidly expanding involving millions for investments every year. This business,as well as the lumbering industry is looking to permanent supplies of forest products to stock their mill and before engaging upon reforestation enterprises are anxious to know the hields that may be expected from timber growing. The species most suitable for pulp in this region are sitka spruce and western hemlock. Located on the coast region in an extremely humid belt, they occupy good growing sites and promise large yields in a short rotation. However, there is practically no information regarding their development in spite of the demands which have been coming in year after year for such knowledge from foresters, investors and industrialists. If the Pacific Northwest Forest Experiment Station cannot undertake the study soon, it will be failing in one large feature of

public service and will jeopardize its position as a leader of forestry research in this region. Estimated expenditure for F.Y. 1933 and for two years thereafter is $7,500 per year or $22,500.

(c) The standard procedure of making yield studies of even aged forests stands will be followed, amplified somewhat by special emphasis of yields of understocked, slightly uneven-aged stands since this kind of stand is prominent in the "Fog Belt". More emphasis than usual will be placed upon the quality of the timber by making detailed description of the character of the bole, the clear lengths, the position and size of branch stubs below the live crown and other factors which have been given too little emphasis in past growth studies.

(d) Much work has been done in Alaska and in British Columbia on the growth of spruce and hemlock in analogous forest type. It will be the plan to combine the data taken in Oregon and Washington with the data for the extension of this region to the north, thus greatly increasing the usefulness of the final results to all parties.

(e) Much data usable for the study already available in British Columbia and Alaska (See above.) Measurements were taken several years ago on seven plots, two of which were permanently located for future remeasurement.

6. Forest Survey of Eastern Oregon and Eastern Washington

(a) To make a forest survey of eastern Oregon and Washington as part of the national survey of forest resources.

(b) The western yellow pine region of eastern Oregon and Washington contains over 20 million acres, about three quarters of which is public land. It carries a stand of over 130 billion feet and is one of the important timber producing regions of the country, both present

and prospective. Reliable information is lacking on the existing forest conditions, and is greatly needed in order to put these on a sound basis for permanent production and community and industrial welfare. It is logical to make the survey of this region as soon as the Douglas fir region in the western parts of these states is completed. The contacts are already made, cooperation is set up, the organization on hand, plans and methods are perfected, the present personnel could probably do this region in about one and one-third years. The cost of the project is estimated to be $100,000. exclusive of assured cooperation.

(c) It is planned to do the work using the same methods used in the Douglas fir region.

(d) Cooperation with State Foresters, fire protective associations, individual lumber companies and timberland owners, the Indian Service, National Park Service, the National Forest organization, etc., would be obtainable as has been the case in doing the western parts of these same states.

(e) No work of this nature under way in eastern Oregon and Washington.

7. Forest Economic Study of New Public Domain in Oregon and Washington

(a) To determine the present and prospective acreage of forest and farm land reverting to some form of public ownership in the two states. To determine its location, what effects it will have on local government, what the states and counties are doing or are preparing to do about the situation, and to recommend ways and means of relieving or remedying the situation.

(b) Delinquency is at hand and is increasing. There is between 1,500,000 and 2,000,000 acres of it in Oregon and Washington. In one

heavily logged county the delinquency is 25% of the total assessed acreage. Oregon just passed a law allowing the state to take over such lands from the counties. Now is the time to get the facts so as to steer the proper course. Forest survey has the facts as to land use. Two permanent men and 12 months of field assistants would, at a total cost of $9800, in one year make a very useful study of this problem.

(c) Plan to map in place delinquency by 1, 2, 3, 4, and 5 year classes, also map in place intent in ownership and assessed valuation. These maps together with the forest survey maps of present land use and ownership would give all the correlations necessary and would indicate where to expect various degrees and amounts of delinquency. The total annual tax income of the various counties will be an index of the probability of the counties handling the problem. From this point on, the problem is one of suggesting ways and means.

(d) Could anticipate cooperation from State Foresters, State Tax Commission, County Officers, State land officers.

(e) No specific work of this nature under way in the region, although the Forest Survey of the Douglas fir region, the proposed survey of the pine region and the studies of sample counties by the Forest Taxation Inquiry give valuable ground work for this study.

8. Forest Insurance in the Western Yellow Pine Region

(a) Extension of the forest insurance study, now under way in the Douglas fir region of Oregon and Washington, to the western yellow pine region of these states and adjacent portions of Idaho and California.

(b) The forest insurance study now being conducted in the Douglas fir region of Oregon and Washington should soon be extended to the

adjoining yellow pine region. This region contains upwards of five and one half million acres of privately owned forest land estimated to carry more than fifty billion feet of merchantable timber of which seventy percent is western yellow pine. A large acreage is covered with potentially very valuable stands of natural reproduction. Fire protection in this region is as intensive and effective as it is in the Douglas fir region. The insurance study has already made helpful cooperative contacts with State Foresters and the protective organizations of Oregon and Washington which will be of great importance in expediting the work in the yellow pine region. The importance of the region economically and forest-wise makes the early availability of forest insurance highly desirable. The stage is particularly well set for the introduction of the study. Estimated cost $10,000.

(c) The work will comprise the determination of fire hazard by forest types in their relation to physical conditions in and adjacent to them with particular reference to the influences of climate and protection. This will be accomplished through a complete study of fire losses that have occurred in past periods, based on the existing fire records, special field damage studies conducted by the personnel of the insurance study itself, and supplementary detailed fire data that will be collected to meet the particular needs of the study. These data will be collected in such form that it will be possible to analyze them statistically to show the relative amounts of hazard due to the measureable variable elements so that detailed rating schedules can be constructed which could be used in practical underwriting. Administrative problems of forest insurance will also be studied. In this connection a saving can undoubtedly be effected if this phase of the

work can be conducted in the yellow pine and Douglas fir regions concurrently since several of these problems are common to both regions.

(d) Cooperation can be definitely relied on from several agencies including the State Forest organizations, the protective associations, the Western Forestry and Conservation Association, and a number of private organizations.

(e) This project will be a natural follow-up of the insurance study in the Douglas fir region, since the fundamental principle of insurance is the spreading of risk over a wide territory and range of conditions. It will tie in well with the forest survey of the same region which it is hoped to do concurrently. The insurance study of the pine region will be much facilitated by certain fire studies and fire report analyses which are now under way, and the results of which will be available by the time this proposed project is begun.

## REPORT ON STUDIES BY FOREST PERSONNEL

### A Review of the 1930 Forest Studies Assignments and Assignments for 1931.

This review of studies by Forest personnel covers the investigations listed as "Minor Studies" on pages 79 to 84 inclusive, of the report for 1929 and program for 1930, of the Regional Investigative Committee, together with assignments for 1931. After each study is shown in parentheses the Branch responsible for initiating action and for providing the necessary supervision and contact.

In the set-up of these Forest studies, such as carried on by the Forest personnel, the projects are placed into two classes:

1. Sub-Assignments of Major Projects, which are major studies under the Branch of Research or a Regional Branch having certain phases being worked out by Forest personnel, or on which aid is furnished by Forest personnel on these major projects under the immediate direction of one or another of these Branches.

2. Administrative Studies, such as discussed in the report of the Regional Foresters' Conference and the Forester's comments thereon, held at Washington, D. C., March 17 to April 9, 1930, which are defined in this report as:

"a. Projects of purely local nature involving the application of the results of research.

"b. Projects of purely local nature involving readily determinable facts necessary to immediate application in administration.

"c. Projects of local nature the results of which may be applicable Service-wide or to forest regions and which can not be undertaken by Research for some years."

### Sub-Assignments of Major Projects

Note: These studies are described under their appropriate headings in the discussions pertaining to the major projects. Those starred (*) have not been previously listed in this program.

1. Methods of Cutting Western Yellow Pine (EXP)

Assigned to Crater, Deschutes, Malheur, Whitman and Fremont Forests.

2. Natural Reproduction, Douglas Fir Region (EXP)

a. Germination and survival on different sites. Cascade and Rainier Forests.

b. Seed tree survival. Cascade, Mt. Baker, Mt. Hood, Olympic, Santiam and Snoqualmie Forests.

3. Thinnings in Douglas Fir (EXP)

Assigned to Cascade, Olympic and Siuslaw Forests.

4. Thinnings in Western Yellow Pine (EXP)

Assigned to Chelan, Fremont, Malheur, Ochoco, Umatilla and Whitman Forests.

5. Phenological Observations (EXP)

All west side Forests in Region 6. Cascade, Columbia Crater, Mt. Baker, Mt. Hood, Olympic, Rainier, Santiam, Siskiyou, Siuslaw, Snoqualmie and Umpqua.

6. Planting and Seeding Secondary Species (FM)

a. Sites suitable for noble and silver fir. Mt. Hood and Rainier Forests.

b. Western yellow pine planting. Crater and Umpqua Forests.

c. Direct seeding in fog belt with small-seeded species. Olympic Forest.

d. Alder strips for firebreaks on cut-over areas. Olympic Forest.

7. Field Planting, Douglas Fir (FM)

a. Effect of site and brush cover on survival. Columbia and Rainier Forests.

b. Damage to plantations by animal trampling and cropping. Olympic and Rainier Forests.

c. Season of planting. Rainier Forest.

8. Adaptability of Exotics and Native Species Outisde of their Natural Ranges (FM)

Cascade, Columbia, Deschutes, Fremont, Olympic, Rainier and Siuslaw Forests.

9. Douglas Fir Nursery Practice (FM)

a. Production of satisfactory grade of seedling stock for planting. Columbia, Olympic and Rainier Forests.

10. Reporting and Charting Lightning Storms (EXP)

Assigned to all Forests in the North Pacific Region.

11. Static as an Indicator of Fire Weather (EXP)

Chelan, Deschutes, Fremont, Mt. Hood, and Whitman Forests.

*12. Analysis of Time Factors in Fire Control (EXP. FC)

Colville, Deschutes, Rainier, Wallowa, Wenatchee, Whitman Forests.

13. Fire Suppression Equipment (FC)

a. Felling of snags by machine drilling and powder. Assigned to Columbia, Mt. Hood, Malheur, and Rainier Forests.

*14. Torches for Back-firing (FC)

Assignment to such Forests as conditions may warrant during the season.

15. Forest Survey of Douglas Fir Region (EXP)

Assigned to Cascade, Columbia, Crater, Mt. Baker, Mt. Hood, Olympic, Santiam, Siuslaw, Snoqualmie and Umpqua Forests.

*16. Selective Logging in the Douglas Fir Region (EXP)

Snoqualmie and Olympic Forests.

*17. Climatic Factors in Relation to Bark Beetle Epidemics (ENT)

Chelan, Colville, Deschutes and Malheur Forests.

## Administrative Studies

1. Cascara (FM)

Assigned to Siuslaw Forest. Field work completed and reports prepared by Wilcox sent to Prof. T. J. Starker, Oregon State College, for joint report. Will be completed in 1931.

2. Port Orford Cedar (FM)

Assigned to Umpqua and Siskiyou. Considerable mensurational and silvical data obtained by Matthews and Jackson, but due to transfer of former to Resource Survey, progress on this study has been somewhat held up. Further observations on silvical, cutting, and slash disposal phases desired before report is prepared. Continued on both Forests for 1931.

*3. Alaska Cedar (FM)

Assigned to Mt. Baker, Mt. Hood, Olympic, Rainier and Snoqualmie. A mapping of the location and approximate areas of stands of Alaska cedar by men on the Resource Survey, as incidental work. Preparatory to making a silvical study of this little known and valuable species.

*4. Cottonwood Study (FM)

Assigned to Cascade, Columbia, Mt. Baker, Mt. Hood, Olympic, Rainier, Santiam, Siuslaw, Snoqualmie. Mapping of location and area of cottonwood stands in connection with Resource Survey.

*5. Western Yellow Pine Volume Table Check (FM)

Assigned to Chelan and Wenatchee. A tree volume check against the Site IV western yellow pine volume table as used in Region 6. Thus far we have no check of this table of trees in the pine stands in Washington, and question has been raised on the Wenatchee concerning its accuracy.

*6. Slash Disposal Methods and Costs on Private Lands (FC, FM)

Assigned to Malheur, Rainier, and Wenatchee. A study of slash disposal methods and costs for cutting operations on private lands in cooperation with National Forest cuttings. Costs, methods and results will be studied.

7. Swamper Burning in Western Yellow Pine (FM)

Study assigned to Colville, Deschutes, Fremont, Wallowa, Whitman, and Malheur Forests. In 1930 the Deschutes Forest attempted the method on a small scale. No other reports were submitted. This study is now assigned to all Forests on the east side where small yellow pine sales are in progress.

8. Natural Reproduction, Western Yellow Pine (FM)

Assigned to Wallowa Forest. Examination made in 1930 on seedling survival and slash deterioration. Results to date show practically no reproduction established since 1925. Report prepared. Recommended study be continued.

9. Natural Reproduction, Douglas Fir (FM)

Assigned to Snoqualmie in 1930 and extended to the Columbia for 1931. Progress report prepared in 1930 for the Snoqualmie observations. With the heavy 1930 seed crop valuable information should be obtained in 1931 and succeeding years.

*New studies not previously listed.

10. Thinning sapling lodgepole pine (FM)

Assigned to Wallowa and Whitman Forests. Two plots thinned in 1928. Data compiled and progress report prepared in 1930. New assignment to Whitman with inclusion of study of the vegetational phases.

11. Thinning Sapling Larch, Douglas Fir (FM)

Assigned to Colville Forest. No work done in 1930. The Colville plans to establish a plot during 1931 if time and conditions permit.

12. Afforestation of Treeless Areas (FM)

Assigned to Wenatchee for a study of the possible afforestation of treeless areas. Annual examinations made of planted stock.

13. Fire Damage, Fog Belt Region (FC)

Assigned to Olympic. Study of fire damage to timber burned in 1927. Plot established and annual reports as to condition of trees and mortality by species made. Continued indefinitely.

*14. Disposal of Port Orford Cedar Slash (FC)

Assigned to Umpqua and Siskiyou. There is immediate need of knowledge concerning the methods, costs, necessity, rating of hazard, etc. in the selectively cut mixed stands of Douglas fir, Port Orford cedar, hemlock, in the Coos Bay region.

*15. Visibility of Class A Smokes (FC)

Assigned to Cascade, Chelan, Columbia, Colville, Crater, Deschutes, Fremont, Mt. Hood, Umatilla. The effectiveness of discovery of small smokes by lookouts is very important, and the elapsed time between the starting of a smoke and its interception by the lookout, and the maximum distance it can be spotted should be known for the most effective protection.

*16. Eliminating Hazards in Moss and Insect-killed Timber by Winter Burning

Assigned to Fremont and Ochoco. A study of snag-disposal by burning during periods of low fire hazard.

17. Grazing Management of Cut-over Areas (RM, FM)

Assigned to Columbia, Crater, Siskiyou and Wenatchee Forests. Grazing phases on Columbia completed and merged into the Douglas fir natural reproduction study. Examination made as to plant successional phases and reproduction on other three Forests. Continued in 1931 on Crater, Siskiyou and Wenatchee.

18. Plant Succession (RM)

A grouping of five studies of plant succession on comparable grazed and protected plots on which concrete observations are being made. This general subject is divided into the following phases:

a. Seasons of Grazing: A permanent assignment to all important grazing Forests. Continued indefinitely.

b. Mountain Meadows (deferred use): Assigned to Cascade, Mt. Baker Mt. Hood, Snoqualmie, Umpqua. This is a study bearing upon grazing use where recreational interests may conflict either at present or in the future. Continued indefinitely.

c. Gopher-controlled Areas: Assigned to Ochoco in cooperation with Biological Survey. No work done in 1929 and 1930 due to excessive drought conditions making gopher poisoning of doubtful success. Continued in 1931.

d. Erosion-controlled Areas: Assigned to Fremont and Ochoco. A study brush and other control measures of meadow erosion and observations of plant succession on recovered areas. Report on Fremont in process of preparation for dissemination to other Forests that may be interested in this work. Total of 32 dams constructed on Ochoco. Continued on same Forests in 1931.

e. Burned timber areas: Assigned to Umatilla. A study of plant succession on a burned-over area to study (1) Forest regeneration, (2) reduction of range by fire, (3) length of period of effect of fire on regeneration and forage. Area examined in 1930 and report submitted. Continued in 1931.

*19. Sheep Trucking vs. Trailing (RM)

To Chelan, Malheur, Ochoco, Umatilla, Wenatchee and Whitman. A study of the comparative costs and shrinkage of lambs trucked vs. trailing to market points.

*20. Range Reseeding (RM)

Assigned to Chelan. A study of grass seeding on denuded areas as a means of restoring range.

*21. Carrying Capacity of Ranges (RM)

Assigned to Wenatchee. Correlation of carrying capacity with actual use records.

*22. Effect of Beaver Work on Range (RM)

Assigned to Ochoco. A study of range conditions as affected by beaver activities.

*23. Relation of Grazing to Plant Growth on Newly Grazed Area (RM)

Assigned to Deschutes Forest. A study of a newly grazed area in the Fort Rock district with reference to securing maximum reduction of fire hazard, avoiding damage to tree reproduction, and maintaining forage at its maximum productivity.

*24. Economics of Caterpillar Hauling (O)

Columbia, Mt. Hood and Olympic. Adaptability of Caterpillar hauling of supplies in regions of difficult access, as compared to automobile or pack stock. Factors such as cost, speed, reliability, load, road construction, etc. will be considered.

*25. Truck Tire Study; Dual, Single Tandem (O)

Assigned to Chelan, Crater, Olympic. A comparative study of tire costs on Forest roads, according to whether used single, dual, or tandem fashion.

*26. Tree Removal Costs and Results by Pulling, Cutting and Blasting.(O)

Assigned to Deschutes, Santiam, Siuslaw, and Umpqua Forests. A study to determine relative costs and effects of tree removal by these three methods under various conditions in Forest road construction.

*27. Way and Motor-Way Grades (O)

Assigned to Columbia, Crater, and Siskiyou Forests.

*28. Use of Explosives (O)

Assigned to Columbia, Mt. Hood, and Rainier Forests. A study of the classes of explosives and methods best adapted under various conditions of Forest road construction.

*29. Rock Drilling Methods (O)

Assigned to Columbia, Crater, Mt. Hood, and Olympic Forests. A determination of methods conducive to best results under various conditions.